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SPECTRAL ABSORPTION COEFFICIENTS OF CARBON, NITROGEN, AND OXYGEN ATOMS

by

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FOREWORD

The work described in this report was carried out for the National Aeronautics and Space Administration, Ames Research Center, Moffett Field, California, 94035, under the terms and specifications of their Contract NAS 2-3496.

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ABSTRACT

The spectral absorption coefficients of neutral and singly ionized carbon nitrogen, and oxygen atoms are presented. The continuum contributions resulting from bound-free and free-free transitions are presented in terms of an effective cross section summed over all permissible initial and final states. These effective continuum cross sections are tabulated spectrally over a frequency range $0.25\ \text{eV} \leq h\nu \leq 20\ \text{eV}$ for temperatures in the range 3,000°K to 24,000°K at 1,000°K intervals. The discrete, i.e. line, contributions resulting from bound-bound transitions are presented in terms of tabulations of absorption f-numbers for all significant transitions (multiplet, supermultiplet, and transition arrays). Electron impact (half) half-widths and line shifts for Lorentzian line shapes are tabulated for all significant transitions for temperatures in the range 2,500°K to 25,000°K.

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NOMENCLATURE

$b_{nn'}$	normalized line shape function
CI	spectroscopic notation for neutral carbon atoms
CII	spectroscopic notation for singly ionized carbon atoms
$C_{11'}$	algebraic factor obtained from integration over spin and angular coordinates
c	velocity of light in vacuo, 3.00×10^{10} cm/sec
$d_{nn'}$	electron impact line shift
e	electronic charge, 4.80×10^{-10} esu
$f_{nn'}$	absorption f-number
f(v)	Maxwellian velocity distribution
G^z_{11}	numerical quantity tabulated in Ref. 9
$\bar{q}$	average Gaunt factor
h	Planck constant, 4.135×10^{-15} eV sec
$h\nu$	frequency variable in eV units
K^z	Kramer's semiclassical cross section
k	Boltzmann constant, 8.617×10^{-5} eV/°K
L'	total angular momentum of the electron-atom system in the final state
1, 1'	orbital angular momentum of initial and final states for bound-free transitions
1_n, $1_{n'}$	orbital quantum numbers for electron in states n, n'
m	electron mass, 9.11×10^{-28} gm
N	particle number density
NI	spectroscopic notation for neutral nitrogen atoms
NII	spectroscopic notation for singly ionized nitrogen atoms
$\bar{n}$	effective quantum number
OI	spectroscopic notation for neutral oxygen atoms
OII	spectroscopic notation for singly ionized oxygen atoms
P_n, $P_{n'}$	radial wave functions for atomic system in states n, n'

Q	partition function
Ry	Rydberg constant, 13.60 eV
r	radial coordinate in dipole integral evaluation
T	temperature
u_o	nondimensional ionization energy
u	nondimensional frequency, $h\nu/kT$
u_g	nondimensional threshold frequency for integration over excited states
v	electron velocity
Z	charge on residual ion
Γ	ratio of partition functions in Biberman's theory
$\gamma_{nn'}$	electron impact line width
γ	parameter taken from Ref. 10
μ	absorption coefficient
$\mu_{n'}$	effective quantum number, Eq. (3.6)
σ	cross section
σ_o	dimensional constant, Eq. (2.3)
ν	frequency variable
ϵ	normalized energy of free electrons
ϕ	numerical quantity tabulated in Ref. 9
χ	ionization energy from ground state
$\delta_{l'}$	phase shift
ω	wave number
ξ	nonhydrogenic function in Biberman's theory
ζ	normalization factor for bound state

Subscripts:

k	denotes species
i, j	initial, final states for bound-free transition
i', j'	initial, final states for free-free transition
n, n'	initial, final states for bound-bound transition
e	denotes free electrons

Superscripts:

k	denotes species
b-f	bound-free transition
f-f	free-free transition
b-b	bound-bound transition
C	continuum contribution
T	threshold value

Section 1
INTRODUCTION

The ability to predict radiant energy transfer is essential in the study of shock-heated plasma flows. In the case of bodies entering planetary atmospheres at high velocities (roughly greater than 10 km/sec), radiation transport is significant in determining the shock-layer structure and surface energy transfer. A knowledge of the frequency-dependent absorption properties of the constituent species is required in these quantitative studies of radiation transport.

Theoretical methods for calculating the spectral absorption coefficients of atomic plasmas of light elements are now well developed (Ref. 1). These methods have been applied previously to opacity calculations for nitrogen and oxygen atoms (Ref. 2) and recently to carbon atoms. The results of this work are summarized in this report in terms of detailed tabulations of spectral absorption coefficient data for neutral and singly ionized carbon, nitrogen, and oxygen atoms.* These atoms, along with hydrogen, for which the requisite spectral data are available (Refs. 1 and 4), are likely to be the dominant atomic species in planetary entry problems or problems involving surface mass injection from hydrocarbon-based ablation heat shields. Hence, this report provides a necessary counterpart to existing tabulations of molecular opacities of H, C, N, and O mixtures. (See, for example, Refs. 5, 6, and 7.)

For atomic systems, photon absorption results from the interaction of free-free, bound-free, and bound-bound electron transitions with the radiation field. The first two processes give rise to a continuous variation of absorption coefficient with photon

*The standard spectroscopic notation of representing the ionized state of an atom by a Roman numeral following the atomic symbol (Ref. 3) is used in this report. Hence, the neutral nitrogen atom is written NI, the singly ionized nitrogen atom NII, etc.

frequency, while the latter process in principle occurs only at a discrete photon frequency and gives rise to line absorption. The absorption coefficient for species k can be written as (Ref. 2)

$$\mu_k(h\nu) = \sum_{i,j} N_i^k \sigma_{ij}^k (h\nu) \tag{1.1}$$

where N_i^k is the number density for lower state i of species k, and $\sigma_{ij}^k (h\nu)$ is the frequency dependent* cross section for photon absorption resulting from a transition from state i to j of species k. Following common practice, the continuum absorption coefficient is presented separate from the line absorption coefficient; in Section 2 we discuss the calculation of free-free and bound-free cross sections, and in Section 3 the calculation of bound-bound cross sections.

Both the effective bound-free cross sections introduced in Section 2 and line width calculations discussed in Section 3 rest upon the assumption of local thermodynamic equilibrium at a specified temperature. Accordingly, data are presented at selected temperatures in the range from 3000°K to 24,000°K. It is intended that the data tabulated in this report will be adequate for radiation transport problems in which the local temperature is less than 24,000°K (kT ~ 2 eV). Using this temperature as a guide, cross sections for photon frequencies covering a range of 0.25 to 20 eV are tabulated. The lower frequency limit is set by limitations on the bound-free continuum absorption coefficients. These limitations result from uncertainties in the populations of the very high excited states without proper accounting of plasma interactions. However, the lower limit of 0.25 eV will be adequate for the large class of radiation transport problems where little energy is transported at frequencies lower than 0.25 eV. The upper frequency limit reflects the fact that for a blackbody source at a temperature of 2 eV, over 99 percent of the total radiated power is emitted at frequencies below this upper limit.

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*Throughout this report, the unit of frequency used is the energy unit $h\nu$ in electron-volts (eV). In addition, it will often be convenient to express temperature as an energy unit kT in electron-volts, k being the Boltzmann constant, 8.6170×10^{-5} eV/°K.

Tabulations of the spectral absorption properties of carbon, nitrogen, and oxygen atoms are given in Section 4. The first set of tables presents the total effective continuum cross section. The second set of tables lists the line transitions and the corresponding transition f-numbers. The final set of tables lists the line transitions and the temperature dependent electron impact half-width and line center shift for these transitions.

Section 2
CONTINUUM ABSORPTION CROSS SECTIONS

2.1 THEORETICAL METHODS

The continuum absorption coefficient is determined from the general expression

$$\mu_k^C = \sum_{i,j} N_i^k \sigma_{ij}^{b-f} (h\nu) + \sum_{i',j'} N_i^k \sigma_{i',j'}^{f-f} (h\nu) \tag{2.1}$$

where $\sigma_{i,j}^{b-f} (h\nu)$ is the frequency-dependent cross section for photon absorption resulting from an electron transition from bound state i to a free state k; and similarly, $\sigma_{i',j'}^{f-f} (h\nu)$ is the frequency-dependent cross section for photon absorption resulting from an electron transition from free state i' to free state j'.*

The bound-free and free-free transitions for each atomic state i can be summed over all accessible final states. Thus,

$$\sigma_i (h\nu) = \sum_j \sigma_{i,j} (h\nu)$$

There are far too many states i for the complex atoms of interest to tabulate detailed $\sigma_i (h\nu)$ values for each individual state. Instead, an effective total continuum cross section is tabulated for each species k as defined by

$$\sigma_k^C (h\nu) \equiv \frac{\mu_k^C (h\nu)}{N^k} = \sum_i \frac{N_i^k}{N^k} \sigma_i^{b-f} (h\nu) + \sum_{i'} \frac{N_{i'}^k}{N_k} \sigma_{i'}^{f-f} (h\nu) \tag{2.2}$$

where N^k is the total number density of species k.

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*The free state of an electron considered for photon absorption is the state of a paired electron-ion system with the electron in the continuous spectrum of energy levels. Hence, the free-free absorption coefficient is calculated in terms of a specific electron-ion pair.

Only under local thermodynamic equilibrium, where the relative populations of states N_i^k/N^k are uniquely specified by the local temperature, can the summations in Eq. (2.2) be evaluated in a reasonable manner. Hence, the effective cross-section data in this report are restricted to systems in local thermodynamic equilibrium and are tabulated at selected temperatures.

Armstrong and his co-workers have developed a computer code (PIC) for calculating bound-free (photoionization) cross sections for the states of nitrogen and oxygen atoms (Ref. 2). To the authors' knowledge, this work is the first systematic calculation of bound-free cross sections using nonhydrogenic theory for the large number of states necessary to determine detailed spectral absorption coefficient data. The tabulated effective continuum cross-section data presented for nitrogen and oxygen are taken directly from these detailed photoionization calculations together with free-free cross sections calculated according to the theory outlined below. A summary of the theory underlying the PIC code (described in detail in Ref. 2) is also presented below.

Similar detailed photoionization cross-section calculations are not available for carbon atoms. Biberman (Ref. 8) has developed a method for calculating continuum cross sections of complex atoms (both bound-free and free-free) using an approximate version of the basic Burgess-Seaton theory underlying the Armstrong calculations. Biberman's method was used to calculate the continuum cross sections for carbon which are tabulated in this report. It should be noted that the approximate theory agrees well with the detailed Armstrong results. Hence Biberman's formulae provide closed-form expressions which are quite convenient in radiation transport calculations.

2.1.1 Full Numerical Calculation of Continuum Cross Sections

The cross sections for the individual states are of the form

$$\sigma_i^{b-f}(h\nu) = \sigma_i^{b-f}(h\nu) \quad \text{for} \quad h\nu \geq h\nu_i^T$$

$$\sigma_i^{b-f}(h\nu) = 0 \quad \text{for} \quad h\nu < h\nu_i^T$$

where the threshold frequency for each bound state $h\nu_i^T$ depends on the ionization energy of that state. In the frequency range of interest, the primary contributions to the effective cross section come from the near-threshold regions of the contributing states. A theory for near-threshold transitions has been developed by Burgess and Seaton (Ref. 9). They present the photoionization cross sections of the individual states in the parameterized form

$$\sigma_i^{f-b}(h\nu) = \sigma_o \sum_{\ell' = \ell \pm 1} C_{\ell\ell'}(L') \frac{G_{\ell\ell'}^2(\nu) \cos^2 [\varphi(\ell, \ell', \nu; \epsilon) + \delta_{\ell'}(L', \epsilon)]}{\left[1 + \epsilon\nu^2\right]^{[\gamma_{\ell\ell'}(\epsilon) - 1]}} \tag{2.3}$$

where the dimensional constant σ_o is given by

$$\sigma_o = \frac{8.55 \times 10^{-19}}{\zeta(\bar{n})} \left(\frac{\bar{n}}{Z+1}\right)^2 \text{cm}^2$$

where $\bar{n}$ is the effective quantum number defined by

$$\bar{n} = (Z+1)\left(\frac{R_\infty}{\chi_i}\right)^{1/2}$$

and where the quantities $C_{\ell\ell'}(L')$, $G_{\ell\ell'}$, ψ and γ were obtained from tables or analytic expressions given in Ref. 9. The normalization factor $\zeta(\bar{n})$ and the phase shift

$\delta(L', \epsilon)$ were estimated from information on the bound states of the ion.* The quantity χ_i^Z is the ionization energy of the ith state.

In principle, one can use Eq. (2.3) and tables of populations to evaluate Eq. (2.2) directly. In practice, this is quite difficult (and unnecessary) due to the very large number of states involved. The approach taken in the present calculation was to include the low-lying states separately, then to progressively lump the higher lying states into approximately equivalent states of the properly averaged (quantum mechanically) energies. Burgess-Seaton cross sections were used for the low-lying states; hydrogen-like cross sections taken from the work of Karzas and Latter (Ref. 10) were used for the high-lying states. The states included and the energies assigned to them are given in Table 2-1.

The populations of the states were taken from the work of Gilmore (Ref. 11). The population ratios $\left(N_i^k/N^k\right)$ were taken to be density independent and assumed a maximum principal quantum number of 8. A considerably larger number of states were included in the photoionization calculation than were considered by Gilmore. Thus, Gilmore's states were split into component states (as required) according to the statistical weights of the component states. The energy of each component state was taken to be the same as that of Gilmore's original state.

The cross section of each state was evaluated at energies of 0, 1, 2, 4, 8, 10, and 20 eV above its threshold frequency. These data were then stored on tapes. At a given frequency, the cross sections of the contributing states were obtained by logarithmic interpolation between stored values. They were then weighted by the appropriate population and summed to obtain the effective cross section.

The effective cross section σ_k^{f-f} for free-free transitions of electrons in the field of positive ions of charge $Z + 1$ can be written as (Refs. 12, 13)

$$\sigma_k^{f-f}(h\nu) = \sum_{i'} \frac{N_{i'}^k}{N^k} \sigma_{i'}^{f-f}(h\nu) = \frac{N_e N_k^{Z+1}}{N_k^Z} \bar{g} K^Z \tag{2.4}$$

*The reader is referred to Ref. 2 for the details of this calculation.

Table 2-1

ATOMIC STATES OF NITROGEN AND OXYGEN ATOMS

Nitrogen		Nitrogen		N^+		N^+	
State	Energy (cm^{-1})	State	Energy (cm^{-1})	State	Energy (cm^{-1})	State	Energy (cm^{-1})
$2s^2 2p^3\ ^4S$	0	5p	112583	$2s\ 2p^3\ ^3P$	109221	4d	339811
^2D	19228.6	5d		^3S	155132	4f	
^2P	28839.9	5f		^1P	166771	$2p^3\ (^4S)\ 3s\ ^5S$	364011
$2s^2 2p^4\ ^4P$	88134.5	5g		$2s^2 2p\ (^2P)\ 3s\ ^3P$	149061	$3s\ ^3S$	
^2D	121003	6s	114204	$3s\ ^1P$	149061	$3p\ ^5P$	
^2S	142114	6p		$3p\ ^3S-D$	169027	$3p\ ^3P$	
^2P	158205	6d		$3p\ ^1S-D$	169027	$3d\ ^5D$	
		6f				$3d\ ^3D$	
$2p^5\ ^2P$	232908			$3d\ ^3P-F$	187699	4s	396012
		6g−h				4p	
$2s^2 2p^2\ (^3P)\ 3s\ ^4P$	83338.5	7−8	115500	$3d\ ^1P-F$	187699	4d	
^2P	86195.5	$(^1D)\ 5s$	127814	4p	208595	4f	
$3p\ ^2S-D$	95782.7	5p		4d		$(^2D)\ 3s\ ^3D$	380012
$3p\ ^4S-D$	95782.7	5d		4f		$3s\ ^1D$	
$3d\ ^2P-F$	104864	5f		$2s^2 2p^2\ (^4P)\ 3s\ ^5P$	234407	$3p\ ^3P-F$	
4s	103864	5g		$3s\ ^3P$		$3p\ ^1P-F$	
4p	107424	6s	129404	$3p\ ^5S-D$		$3d\ ^3S-G$	
4d	110318	6p		$3p\ ^3S-D$		$3d\ ^1S-G$	
4f	110444	6d		$3d\ ^5P-F$		4s	412013
		6f				4p	
$(^1D)\ 3s\ ^2D$	99667.3	6g−h		$3d\ ^3P-F$		4d	
$3p\ ^2P-F$	110977	7−8	130700	4s	266108	4f	
$3d\ ^2S-G$	121003	$(^1S)\ 5s$	145005	4p		$(^2P)\ 3s\ ^3P$	408013
4s	124604	5p		4d		$3s\ ^1P$	
4p		5d		4f		$3p\ ^3S-D$	
4d		5f		$(^2D)\ 3s\ ^3D$	278009	$3p\ ^1S-D$	
4f		5g		$3s\ ^1D$		$3d\ ^3P-F$	
$(^1S)\ 3s\ ^2S$	116282	6s	147005	$3p\ ^3P-F$		$3d\ ^1P-F$	
$3p\ ^2P$	128404	6p		$3p\ ^1P-F$		4s	439014
$3d\ ^2D$	137504	6d		$3d\ ^3S-G$		4p	
		6f				4d	
4s	142004	6g−h		$3d\ ^1S-G$		4f	
4p		7−8	148000	4s	309809	$2s^2 2p\ (^2P)\ 5s$	220507
4d		$2s\ 2p^3\ (^5S)\ 5s$	159005	4p		5p	
4f		5p		4d		5d	
$2s^2 2p^3\ (^5S)\ 3s\ ^4S$	131004	5d		4f		5f	
$3s\ ^6S$	131004	5f		$(^2P)\ 3s\ ^3P$	323110	5g	
$3p\ ^4P$	142004	5g		$3s\ ^1P$		6s	226507
$3p\ ^6P$	142004	6s	161005	$3p\ ^3S-D$		6p	
$3d\ ^4D$	152005	6p		$3p\ ^1S-D$		6d	
$3d\ ^6D$	152005	6d		$3d\ ^3P-F$		6f	
4s	156005	6f		$3d\ ^1P-F$		6g−h	
4p		6g−h		4s	354811	7−8	231000
4d		7−8	162000	4p		$2s^2 p^2\ (^4P)\ 5-8$	286500
4f				4d		$(^2D)\ 5-8$	330200
$2s^2 2p^2\ (^3P)\ 5s$	112583			4f		$(^2P)\ 5-8$	375200
				$(^2S)\ 3s\ ^3S$	308109	$(^2S)\ 5-8$	360200
				$3s\ ^1S$		$2p^3\ (^4S)\ 5-8$	416000
				$3p\ ^3P$		$(^2D)\ 5-8$	432000
				$3p\ ^1P$		$(^2P)\ 5-8$	460000
				$3d\ ^3D$			
				$3d\ ^1D$			
				4s	339811		
				4p			

Table 2-1 (cont.)

Oxygen		Oxygen		O^+	
State	Energy (cm^{-1})	State	Energy (cm^{-1})	State	Energy (cm^{-1})
$2s^2 2p^4\ ^3P$	78	$3s\ ^1D$	258008	$2s\ 2p^4\ ^2P$	212656
^1D	15868.5	$3p\ ^3P-F$		$2s^2 2p^2 (^3P) 3s\ ^4P$	185408
^1S	33793.1	$3p\ ^1P-F$		^2P	189014
$2s^2 2p^5\ ^3P$	126308	$3d\ ^3S-G$		$3p\ ^2S-D$	209215
$2p^6\ ^1S$	277008	$3d\ ^1S-G$		$3d\ ^4S-D$	232570
$2s^2 2p^3 (^4S) 3s\ ^5S$	74905.3	$4s$	268008	$3d\ ^2P-F$	232570
$3s\ ^3S$	74905.3	$4p$		$4s$	239356
$3p\ ^5P$	87382.0	$4d$		$4p$	246867
$3p\ ^3P$	87382.0	$4f$		$4d$	255014
$3d\ ^5D$	97445.9	$(^2S) 3s\ ^3S$	287009	$4f$	255940
$3d\ ^3D$	97445.9	$3s\ ^1S$		$(^1D) 3s\ ^2D$	206979
$4s$	95760.1	$3p\ ^3P$		$3p\ ^2P-F$	229905
$4p$	99317.2	$3p\ ^1P$		$3d\ ^2S-G$	252579
$4d$	102903	$3d\ ^3D$		$4s$	272938
$4f$	102903	$3d\ ^1D$		$4p$	
$(^2D) 3s\ ^3D$	101526	$4s$	298009	$4d$	
$3s\ ^1D$	101526	$4p$		$4f$	
$3p\ ^3P-F$	113604	$4d$		$(^1S) 3s\ ^2S$	226858
$3p\ ^1P-F$	113604	$4f$		$3p\ ^2P$	250259
$3d\ ^3S-G$	123943	$(^2P) 3s\ ^3P$	304009	$3d\ ^2D$	275960
$3d\ ^1S-G$	123943	$3s\ ^1P$		$4s$	296009
$4s$	128704	$3p\ ^3S-D$		$4p$	
$4p$	128704	$3p\ ^1S-D$		$4d$	
$4d$	128704	$3d\ ^3P-F$		$4f$	
$4f$	128704	$3d\ ^1P-F$		$2s\ 2p^3 (^5S) 3s\ ^6S$	249238
$(^2P) 3s\ ^3P$	114419	$4s$	314009	$3s\ ^4S$	249238
$3s\ ^1P$	114419	$4p$		$3p\ ^6P$	270209
$3p\ ^3S-D$	127904	$4d$		$3p\ ^4P$	270209
$3p\ ^1S-D$	127904	$4f$		$3d\ ^6D$	293109
$3d\ ^3P-F$	138004	$2s^2 2p^3 (^4S) 5s$	105403	$3d\ ^4D$	293109
$3d\ ^1P-F$	138004	$5p$		$4s$	313010
$4s$	142104	$5d$		$4p$	
$4p$		$5f$		$4d$	
$4d$		$5g$		$4f$	
$4f$		$6s$	106803	$2s^2 2p^2 (^3P) 5s$	264909
$2s^2 2p^4 (^4P) 3s\ ^5P$	212006	$6p$		$5p$	
$3s\ ^3P$		$6d$		$5d$	
$3p\ ^5S-D$		$6f$		$5f$	
$3p\ ^3S-D$		$6g-h$		$5g$	
$3d\ ^5P-F$		$7-8$	107900	$6s$	271008
$3d\ ^3P-F$		$(^2D)\ 5-8$	134100	$6p$	
$4s$	222075	$(^2P)\ 5-8$	147800	$6d$	
$4p$		$2s^2 2p^4 (^4P)\ 5-8$	227000	$6f$	
$4d$		$(^2D)\ 5-8$	273000	$6g-h$	
$4f$		$(^2S)\ 5-8$	303000	$7-8$	275400
$(^2D) 3s\ ^3D$	258008	$(^2P)\ 5-8$	320000	$(^1D)\ 5-8$	293100
				$(^1S)\ 5-8$	316200
				$2s\ 2p^3 (^5S)\ 5-8$	333000

where N_e and N_k^Z are the number densities of the free electrons and the Zth positive ion of species k, respectively. Kramer's semiclassical absorption coefficient, K^Z, is given by

$$K^Z = \frac{4}{3\sqrt{6\pi}} \left(\frac{2\pi e^2}{hc}\right)\left(\frac{e^2}{mc^2}\right)^2 \left(\frac{mc^2}{kT}\right)^{1/2} \frac{1}{\omega^3} \tag{2.5}$$

and $\bar{g}$ is the Gaunt factor averaged over the Boltzmann velocity distribution of the free electrons. The quantity ω is the wave number in cm^{-1}, and m is the mass of an electron; the other physical quantities are in standard notation.

The Gaunt factor has been calculated by Karzas and Latter (Ref. 10) as a function of the dimensionless parameters u and γ^2 where

$$u = h\nu/kT$$

$$\gamma^2 = (Z + 1)^2 \frac{h\,Ry}{kT}$$

and Ry is the Rydberg constant.

The effective cross section $\sigma_k^{f-f}(h\nu)$ defined by Eq. (2.4) is derived for an electron-ion pair N_e, N_k^{Z+1}. It is convenient to relate the number density of electron-ion pairs to the number density of the parent atom, N_k^Z. In this manner, the free-free cross sections can be assigned to the parent atom and tabulated as part of the total continuum cross section for that atom. Assuming ionization equilibrium,* the Saha equation (Ref. 4) yields

$$\frac{N_k^{Z+1} N_e}{N_k^Z} = \left(\frac{2\pi mkT}{h^2}\right)^{3/2} \frac{2Q_k^{Z+1}(T)}{Q_k^Z(T)} e^{-\chi^Z/kT} \tag{2.6}$$

*The assumption of ionization equilibrium is more stringent, of course, than the assumption of local thermodynamic equilibrium and hence places an additional restriction on the use of the tabulated data.

where χ^Z and $Q_k^Z(T)$ are the ionization energy and partition function, respectively, of the parent atom, and $Q_k^{Z+1}(T)$ is the partition function of the ion. Substituting Eqs. (2.5) and (2.6) into Eq. (2.3) and rearranging slightly yields the desired cross section,

$$\sigma_k^{f-f}(h\nu) = 1.26 \times 10^{-19} \frac{T}{(h\nu)^3} \frac{Q^{Z+1}}{Q^Z} e^{-\chi^Z/kT} \bar{g}(u, \gamma^2) \tag{2.7}$$

where the numerical coefficient has been evaluated from physical constants.

Equation (2.7) has been evaluated at each frequency and temperature and for each atom considered. The partition functions were taken from Gilmore's report (Ref. 11) and are consistent with the occupation numbers used in the PIC code calculation (maximum quantum number of 8). The ionization energies were taken from Moore's tables (Ref. 3). Each Gaunt factor was obtained from the two-dimensional array given by Karzas and Latter by linear interpolation on the logarithm of its independent variables.

2.1.2 Approximate Theory of Biberman

Biberman and Norman (Ref. 8), using the quantum defect method, have devised an approximate theory for continuum cross sections (including both bound-free and free-free transitions) of complex neutral and ionized atoms. The resulting equations have the virtue of simplicity, being as simple as the old hydrogenic expressions, but are considerably more accurate.

The energy levels of a complex atom (for both the bound and free electron states) are divided into two groups: Group A, for which the azimuthal quantum number $\ell \leq 2$; Group B, for which $\ell > 2$. The cross section for states belonging to Group B are considered hydrogenic; those belonging to Group A are calculated using an approximation to the quantum defect method. Define a quantity $\xi(h\nu, T)$ for Group A levels as

$$\mu(h\nu, T) = [\mu(h\nu, T)]_{hyd.} \, \xi(h\nu, T)$$

where the quantity $[\mu(h\nu, T)]_{hyd.}$ is obtained using the hydrogenic cross sections. The function $\xi(h\nu, T)$ is the same for both bound-free and free-free transitions. Calculated values for $\xi(h\nu, T)$ for a number of interesting light elements are presented in Ref. 8. In particular, for carbon, nitrogen, and oxygen atoms (neutral and ionized), ξ is found to be independent of temperature. For all temperatures, therefore, $\xi(h\nu)$ is given by the single frequency function plotted in Fig. 2-1. The scaled frequency variable $h\nu/Z$ (where Z is the charge on the residual ion) is used in Fig. 2-1, which allows $\xi(h\nu)$ for ionized atoms to be shown on the same scale.

In addition to accounting for the nonhydrogenic behavior of the cross sections, Biberman showed that the effects of the increased term structure (both multiplet structure and displaced terms) for a complex atom with several valence electrons can be accounted for by a factor $\Gamma = 2Q_k^{Z+1}/Q_k^{Z}$. Again, Q_k^{Z+1} is the partition function of the residue ion and Q_k^{Z} is the partition function of the parent atom.

Using the ideas briefly described above, the following expressions for the effective continuum cross section for a particular species k are derived in Ref. 8:

$$\sigma_k^C(h\nu) = \frac{6.26 \times 10^{-20}\, \Gamma_k T Z_k^2\, e^{-\left(u_o^k - u\right)} \xi_k(h\nu)}{(h\nu)^3} \; ; \; h\nu \le h\nu_g^k \tag{2.8a}$$

$$\sigma_k^C(h\nu) = \frac{6.26 \times 10^{-20}\, \Gamma_k T Z_k^2\, e^{-\left(u_o^k - u_g^k\right)} \xi_k(h\nu)}{(h\nu)^3} + \sum_{\text{lower states}, i} \frac{N_i^k}{N^k} \sigma_i^{b-f}(h\nu) \; ; \; h\nu \ge h\nu_g^k \tag{2.8b}$$

The limiting frequency $h\nu_g^k$ corresponds to the lowest excited state above which the sum over states required by Eq. (1.1) can be replaced by an integration. Its selection must be based on the term structure of the particular atom under consideration, bearing in mind that it should be valid for all ℓ levels of Group A. For frequencies greater than $h\nu_g$, bound-free transitions from low-lying states having an ionization energy greater than $h\nu_g$ but less than or equal to $h\nu$ must be included specifically.

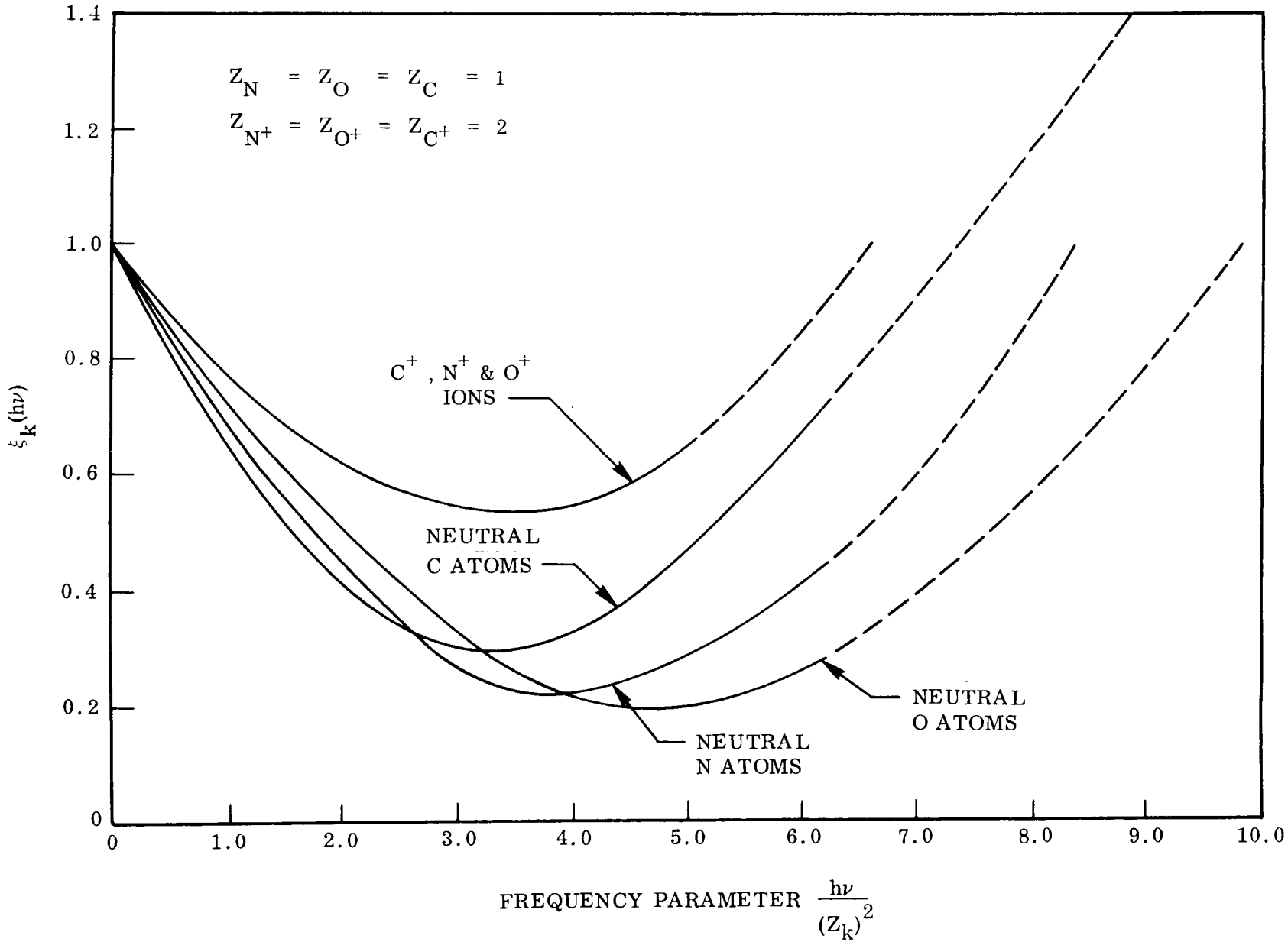

Fig. 2-1 Quantum-Mechanical Correction Factor $\xi_k(h\nu)$

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The cross sections for the relatively small number of individually included states [see Eq. (2.8a)] can be taken from detailed calculations without any significant complication of the approximate method. Moreover, by using relatively exact cross sections for the lower states, the absorption coefficient thus obtained is accurate in the important spectral region where the large photoionization edges occur.

The validity of Biberman's method has been checked by comparing cross sections for neutral nitrogen atoms as calculated from Eqs. (2.8a) and (2.8b) with the detailed data of Armstrong et al. This comparison is shown in Figs. 2-2, 2-3, and 2-4 for temperatures of 10,000°, 15,000°, and 20,000°K. It should be noted that the cross sections for the low-lying states considered individually in Eq. (2.8b) have been taken directly from Armstrong's results. Hence, agreement at high frequencies ($h\nu > h\nu_g$) is effectively guaranteed. However, at low frequencies, where many important states contribute to the summation in Eq. (1.1), the approximate theory provides accurate closed-form expressions for the continuum cross section.

2.1.2 Photoionization Edge Shifts

The continuum cross-section data tabulated in Section 4 have not been corrected for plasma interactions. It is possible to account for such corrections in an approximate manner, thus avoiding tabulation of cross sections (for all temperatures) over a range of density values. The principal result of plasma interactions as far as continuum cross sections are concerned is a shift in the photoionization edges to lower frequencies. Armstrong (Ref. 14) has shown that, in the temperature and density range of interest, the shift is a result of merging of the higher bound state energy levels.* He shows that the frequency shift (in eV) is given by

$$\Delta(h\nu) = \frac{4.71 \times 10^{-6} N_e^{2/7}}{(kT)^{1/7}}$$

*A further discussion of the advance of the series limit is given in Ref. 1.

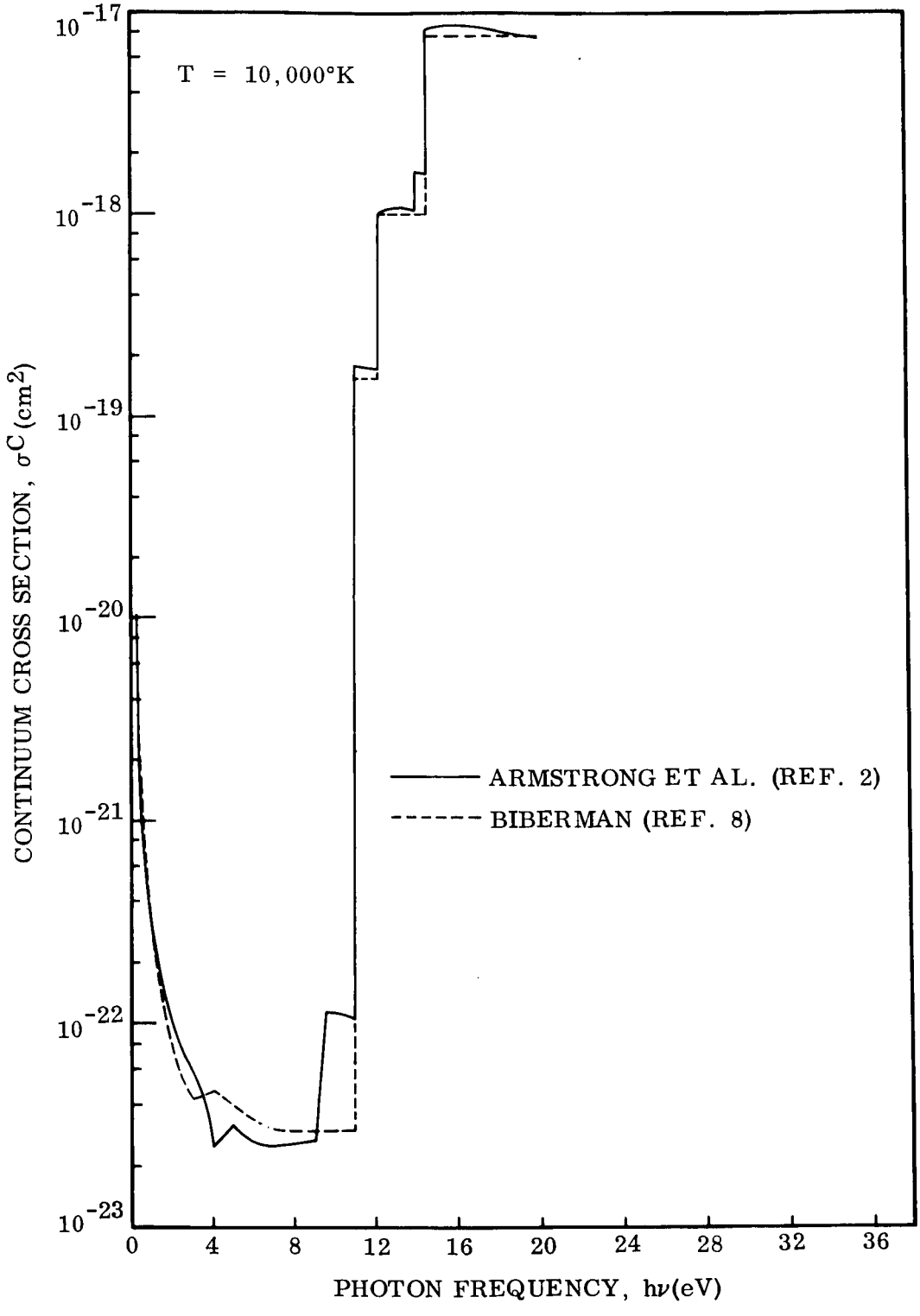

Fig. 2-2 Total Effective Continuum Cross Sections for Neutral Nitrogen Atoms, NI. T = 10,000°K

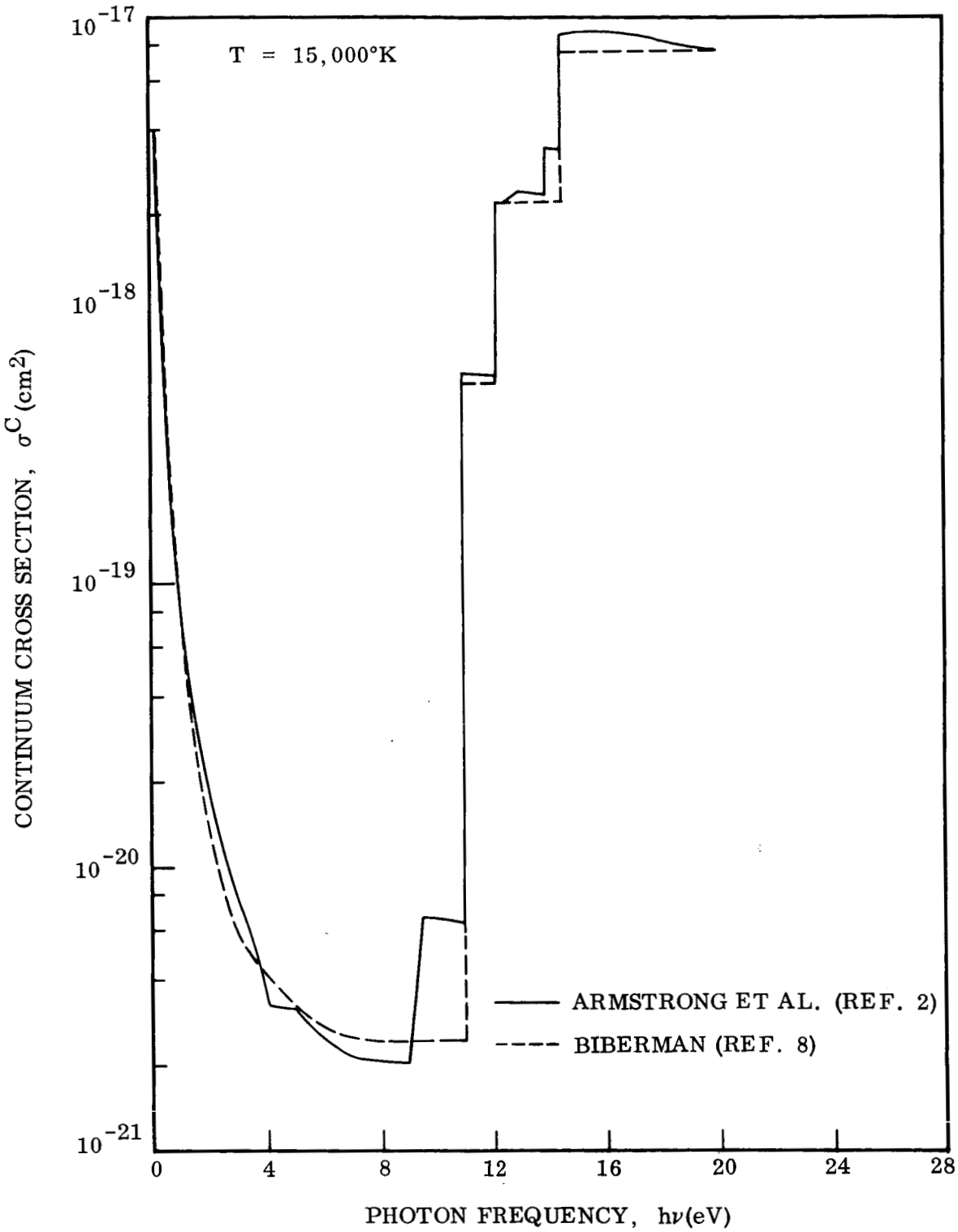

Fig. 2-3 Total Effective Continuum Cross Sections for Neutral Nitrogen Atoms, NI. T = 15,000°K

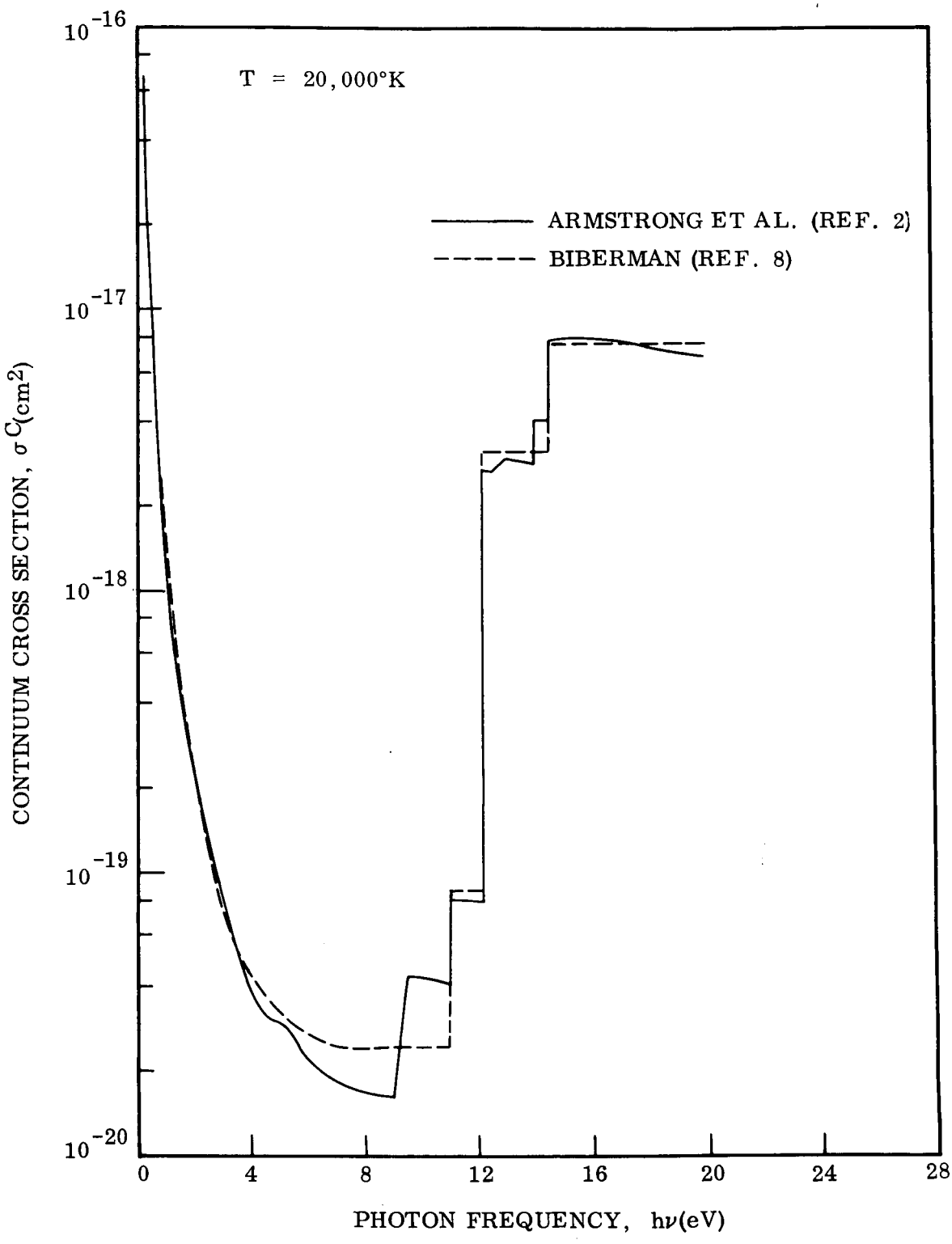

Fig. 2-4 Total Effective Continuum Cross Sections for Neutral Nitrogen Atoms, NI. T = 20,000°K

The effect of the shift at the lower frequencies where the photoionization edges are smeared out is to increase the effective continuum cross section by a factor of $\exp[\Delta(h\nu)/kT]$. Thus, in Biberman's approximate theory, Eq. (9a) of Ref. 8, this exponential factor is introduced. At the higher frequencies, the contribution from the high-lying states is unaffected [the first term in Eq. (9b)]; however, the photoionization from edges of the individually calculated low-lying states [the second term in Eq. (9b)] must be shifted to lower frequencies by the amount $\Delta(h\nu)$. This edge shift at higher frequencies is significant in radiation transport calculations.

2.2 TABULATED DATA ON TOTAL EFFECTIVE CONTINUUM CROSS SECTIONS

Tables 4-1 through 4-6 present the total effective continuum cross section for neutral and singly ionized atoms of carbon, nitrogen, and oxygen at various temperatures. Each table lists the following data: the spectral frequency (i.e., photon energy) in electron volts; the spectral wavelength in Angstrom units; under a specified temperature value in °K, a list of the total effective continuum cross section in square centimeters. For each species, cross-section data are presented for temperatures between 3000°K and 24,000°K in 1000°K intervals.

Section 3
LINE ABSORPTION CROSS SECTIONS

3.1 THEORETICAL METHODS

The line contribution to the absorption coefficient arises when a photon is absorbed as the result of a bound-bound electron transition of the atomic system. Unlike the continuous contribution where an absorption cross section at a given photon energy is determined, the discrete contribution is determined in terms of the total probability for absorption integrated over all photon energies (Refs. 4 and 15),

$$\int_0^\infty \sigma_{nn'}^{b-b}(h\nu)\, d(h\nu) = \frac{\pi e^2}{mc} f_{nn'} \left(1 - e^{-h\nu_{nn'}/kT}\right) \tag{3.1}$$

where $f_{nn'}$ is a dimensionless (absorption) oscillator strength (i.e., the so-called f-number).

Armstrong et al. (Ref. 2) have calculated multiplet, supermultiplet, and transition array f-numbers for transitions in neutral and multiple ionized nitrogen and oxygen atoms. The number of transitions included is complete in the sense that all allowed transitions under L-S coupling are considered. The theoretical methods underlying these calculations are described in Ref. 2. The resulting compilation of f-number data contains much more data than is required for transport calculations. For example, in excess of 2,000 total transitions are listed for nitrogen species. To avoid presenting an excessive amount of data, most of which would not be useful in transport calculations, the transitions have been screened to include only those which are significant based on the rules listed below. First, only neutral and singly ionized atoms are considered since, for temperatures less than 2 eV and at densities where local thermodynamic

equilibrium is likely to be valid, the number densities of doubly or higher ionized atoms is very small. Second, those transitions for which the lower state principal quantum n is greater than or equal to 4 are not listed. These transitions ($n \geq 4$) can be adequately handled by the integral treatment proposed by Biberman and his colleagues (Refs. 16 and 17). Finally, our experience resulting from a detailed investigation of line transport in a nitrogen plasma has shown that for a given transition to be significant, the product of the number density of the lower state,* the f-number, and line width must be comparable to a similar product of neighboring lines.

The existing f-number calculations of Armstrong et al. (Ref. 2) did not include carbon atoms. The available data on transitions in OIII and OIV were used to determine the allowed transitions in CI and CII and corresponding relative multiplet strengths. The dipole integrals required to complete the carbon f-number calculation [see Eq. (4.3) in Ref. 2] were obtained using an existing computer code to calculate Hartree-Fock wave functions.** Calculations were performed for those transitions which our experience with nitrogen indicated would be significant in transport problems.

The selected transitions for carbon, nitrogen, and oxygen atoms are tabulated in Section 4. Included in the f-number tabulations are data from the recent NBS compilation of transition probabilities (Ref. 18). The NBS values are a result of a critical data review program and represent the most reliable data from both experimental and theoretical sources. The NBS f-numbers which are taken from experimental sources are clearly to be preferred over our data. A considerable number of important transitions are not included in the NBS compilation, but the data that are available provide a means of evaluating the accuracy of our theoretical calculations.

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*A convenient tabulation of relative population numbers of the atomic states of nitrogen and oxygen atoms is available in Ref. 11.

**The authors are indebted to Dr. Paul Kelly, Lockheed Palo Alto Research Laboratory, for his generous assistance in making available the computation codes required to calculate dipole integrals for the carbon transitions.

For emission-dominated transport problems, a knowledge of $f_{nn'}$ for all significant transitions is adequate. For the more general case when absorption is important, it is necessary to know the details of the frequency-dependent absorption cross section for each transition, i.e., the line absorption shape. It is convenient to represent the bound-bound cross section $\sigma_{nn'}$ as (Ref. 2)

$$\sigma_{nn'}(\nu) = \frac{\pi e^2}{mc^2} f_{nn'} b_{nn'}(\nu)\left(1 - e^{-h\nu_{nn'}/kT}\right) \tag{3.2}$$

where $b_{nn'}(\nu)$ represents the shape of the line, normalized according to

$$\int_0^\infty b_{nn'}(\nu)\, d\nu = 1 \tag{3.3}$$

For many plasma conditions of interest, the dominant line broadening mechanism is Stark broadening under the electron impact approximation (Refs. 1 and 2). For impact broadening the lines acquire a Lorentz shape (Ref. 2),

$$b_{nn'}(\nu) = \frac{\gamma_{nn'}/\pi}{\left[\nu - (\nu_{o,nn'} - d_{nn'})\right]^2 + \gamma_{nn'}^2} \tag{3.4}$$

where $\nu_{o,nn'}$ is the frequency corresponding to the unperturbed transition from state n to n', $d_{nn'}$ is the shift in the line center, and $\gamma_{nn'}$ is the (half) half-width of the line.

In the line broadening theory outlined in Ref. 2, the following expression is derived for the electron impact half-width.*

$$\gamma_{nn'} = \frac{4\pi N_e}{3} \int_0^\infty \left(\frac{\hbar}{mv}\right)^2 f(v) \sum_m \left\{ \frac{\mathrm{Max}(\ell_{n'}, \ell_m)}{(2\ell_{n'} + 1)} \left[\int_0^\infty P_{n'} r P_m dr\right]^2 \frac{\pi}{\sqrt{3}} g(n', m) \right\} dv \tag{3.5}$$

---

*Note that in Ref. 2 it is pointed out that only the broadening of the upper state n' is considered in the half-width determination. Hence, all transitions to a given upper state will have the same half-width.

where the sum is over all states accessible to electrons with energy $mv^2/2$. In Ref. 2, two basic approximations were made to simplify Eq. (3.5). First, it is assumed that, for essentially all electrons in the Maxwellian distribution $f(v)$, all allowed transitions to states m are accessible. This approximation overestimates the width. The second approximation sets the Gaunt factor $g(n', m)$ to unity, which underestimates the width. Hence, these two approximations taken together tend to compensate the error in each. With these approximations the summation in Eq. (3.5) can be removed from the integral and replaced by the sum rule,

$$\sum_m \left\{ \frac{\mathrm{Max}\,(\ell_{n'}; \ell_m)}{2(\ell_{n'} + 1)} \left[\int_0^\infty P_{n'} r P_m dr \right]^2 = \frac{1}{2} \left(\frac{\mu_{n'}}{Z_{res}} \right)^2 \left[5\mu_{n'}^2 + 1 - 3\ell_{n'}(\ell_n + 1) \right] \right. \quad (3.6)$$

Then the following closed-form solution for the temperature-dependent half-width is obtained,

$$\gamma_{nn'} = \frac{6.37 \times 10^{-23} N_e}{\sqrt{kT(eV)}} \left(\frac{\mu_{n'}}{Z_{res}} \right)^2 \left[5\mu_{n'}^2 + 1 - 3\ell_{n'}(\ell_{n'} + 1) \right] \quad (3.7)$$

Half-widths calculated from Eq. (3.7) when compared with Griem's more detailed solutions (Ref. 1) showed that the above approximations are not applicable in the temperature range of interest. As a result, half-widths were calculated using the general theory of electron impact broadening as set forth in Ref. 1.* The dipole integrals required for a detailed half-width determination were available from the f-number calculations. In most cases, it was found that only the nearest (in energy separation) four or five states had to be included in the summation over available states [see Eq. (3.5)]. It should be emphasized that underlying the electron-impact theory is the requirement that the energy states be isolated. That is, the

*The investigation and subsequent reevaluation of electron impact half-widths was performed by Dr. R. Johnston, Lockheed Palo Alto Research Laboratory.

energy separation between adjacent states must be larger than the broadened width of a given state. Since the broadening increases with increasing electron density, at sufficiently high electron densities overlapping of states will occur, with the result that the calculated line widths are invalid and transitions to these states result in non-Lorentzian line shapes. A comparison of the calculated half-widths with the limited data of Ref. 1 shows agreement to within about 20 percent and a similar temperature dependence.

Electron impact broadening theory (Ref. 1) predicts a shift $d_{nn'}$ in the line center. The line shifts were determined simultaneously with the half-width calculations. The sign convention employed to designate the direction of the line shift is the following: if $d_{nn'}$ is positive, then the line center is shifted to lower frequencies [see Eq. (3.4)].

Results of a series of calculations over a wide temperature range showed that the half-widths and line-shifts (normalized with respect to electron number density) are weakly dependent on temperature. Therefore, over the temperature range of interest it was necessary only to provide calculations at relatively widely spaced intervals. These are chosen as T = 2,500°, 5,000°, 10,000°, 15,000°, 20,000°, and 25,000°K. The half-width and line-shift data tabulated in Section 4 have been divided by the number density of electrons N_e [see Eq. (3.5)] in order to remove the density dependence.

3.2 TABULATED DATA ON ATOMIC LINE TRANSITIONS

Tables 4-7 through 4-12 present a tabulation of the f-numbers for bound-bound transitions in neutral and singly ionized atoms of carbon, nitrogen, and oxygen. Each table lists the following data: a number designating the transition; a code number identifying the lower state; a code number identifying the upper state; the energy difference (in electron volts) between the two states; the corresponding photon wavelength (in Angstrom units); a theoretically determined f-number using LMSC data; and an f-number taken from the NBS compilation. The transitions are listed in order of increasing energy difference.

Each transition is identified by the atomic configuration for the lower and upper states. The atomic configuration is specified by an eight-digit code number (Ref. 2) (ij , kk' , $n\ell$, SL). The ij digits designate the atom and charge state, as follows:

i = 0 oxygen
i = 1 nitrogen
i = 2 carbon

j = 1 neutral
j = 2 singly ionized

The next two digits, kk' , designate the core configuration according to the list provided in Table 3-1 (reproduced from Ref. 2). The n digit is the principal quantum number of the outermost populated shell. The ℓ digit is the orbital quantum number of the outermost populated shell. The S digit is the spin multiplicity, and the L digit is the total orbital angular momentum for Russell-Saunders L-S coupling. When $n' \geq 4$, transitions are summed over all L-S terms and designated $S = 0$, $L = 0$. Hence, for $n' \geq 4$ the transition listed is no longer a single multiplet but rather a sum of multiplets.

As an example of the above identification code, the resonance transition in NI has the following interpretation:

Lower Term (Ref. 3)	Code	Upper Term (Ref. 3)	Code
$2p^3\ {}^4S^o$	1101 2140	$2p^2({}^3p)3s\ {}^3P$	1101 3041

Tables 4-13 through 4-18 present a tabulation of the electron impact half-widths and line shifts for bound-bound transitions in neutral and singly ionized atoms of carbon, nitrogen, and oxygen. Each table lists the following data: a number designating the transition; a code number identifying the lower state; a code number identifying the upper state; the energy difference (in electron volts) between the two states; the corresponding photon wavelength (in Angstrom units); a series of pairs of half-widths and line-shifts (both in electron volts) at specified temperatures.

Table 3-1

ATOMIC CORE CONFIGURATIONS

O-I	$1s^2\ 2s^2\ 2p^3\ (^4S)\,n\ell\,(^{2S+1}L)$	kk' =	01
	(^2D)		02
	(^2P)		03
	$2s\ \ 2p^4\ (^4P)$		04
	(^2D)		05
	(^2S)		06
	(^2P)		07
	$2p^5\ (^2P)$		08
O-II, N-I	$1s^2\ 2s^2\ 2p^2\ (^3P)n\ell\,(^{2S+1}L)$	kk' =	01
	(^1D)		02
	(^1S)		03
	$2s\ \ 2p^3\ (^5S)$		04
	(^3D)		05
	(^3P)		06
	(^1D)		07
	(^3S)		08
	(^1P)		09
	$2p^4\ (^3P)$		10
	(^1D)		11
	(^1S)		12
O-III, N-II, C-I	$1s^2\ 2s^2\ 2p\ \ (^2P)n\ell\,(^{2S+1}L)$	kk' =	01
	$2s\ \ 2p^2\ (^4P)$		02
	(^2D)		03
	(^2S)		04
	(^2P)		05
	$2p^3\ (^4S)$		06
	(^2D)		07
	(^2P)		08
O-IV, N-III, C-II	$1s^2\ 2s^2\ \ \ (^1S)n\ell\,(^{2S+1}L)$	kk' =	01
	$2s\ \ 2p\ \ (^3P)$		02
	(^1P)		03
	$2p^2\ (^3P)$		04
	(^1D)		05
	(^1S)		06

Section 4
TABULATED DATA

In the following sets of tables, the detailed spectral absorption coefficients for neutral and singly ionized carbon, nitrogen, and oxygen atoms are presented. Tables 4-1 through 4-6 give the total effective continuum cross sections for the various atomic species according to the format described in subsection 2.2. Tables 4-7 through 4-12 give the line transitions and f-numbers for the various atomic species according to the format described in subsection 3.2. Tables 4-13 through 4-18 give the line transitions and electron impact half-widths and line center shifts according to the format described in subsection 3.2. The numerical data are presented in floating point notation with an exponent of the base 10 by which the number is multiplied.

Table 4-1

EFFECTIVE CROSS SECTION OF NEUTRAL CARBON, CI (SQ. CM.)

ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 3000	T(DEG-K) 4000	T(DEG-K) 5000	T(DEG-K) 6000	T(DEG-K) 7000	T(DEG-K) 8000
2.000-01	6.200+04	7.38-33	4.36-28	3.35-25	2.90-23	7.20-22	8.15-21
5.000-01	2.480+04	1.32-33	5.84-29	3.76-26	2.90-24	6.53-23	7.06-22
1.000+00	1.240+04	9.10-34	2.48-29	1.20-26	7.62-25	1.51-23	1.45-22
1.500+00	8.267+03	1.48-33	2.50-29	9.01-27	4.72-25	8.18-24	7.07-23
2.000+00	6.200+03	3.48-33	3.61-29	9.74-27	4.21-25	6.35-24	4.95-23
2.500+00	4.960+03	1.02-32	6.55-29	1.32-26	4.71-25	6.19-24	4.35-23
3.000+00	4.133+03	3.64-32	1.44-28	2.17-26	5.37-25	7.30-24	4.62-23
3.500+00	3.543+03	1.56-31	3.79-28	4.28-26	1.04-24	1.03-23	5.90-23
4.000+00	3.100+03	3.34-31	6.20-28	5.96-26	1.29-24	1.19-23	6.43-23
4.500+00	2.756+03	2.75-31	5.09-28	4.89-26	1.06-24	9.80-24	5.28-23
5.000+00	2.480+03	2.43-31	4.50-28	4.33-26	9.39-25	8.56-24	4.67-23
5.500+00	2.255+03	2.23-31	4.13-28	3.97-26	8.61-25	7.95-24	4.28-23
6.000+00	2.067+03	2.07-31	3.84-28	3.69-26	8.02-25	7.40-24	3.99-23
6.500+00	1.908+03	1.93-31	3.58-28	3.45-26	7.48-25	6.90-24	3.72-23
7.000+00	1.771+03	1.80-31	3.33-28	3.20-26	6.94-25	6.41-24	3.45-23
7.500+00	1.653+03	1.67-31	3.09-28	2.97-26	6.45-25	5.95-24	3.21-23
8.000+00	1.550+03	1.67-31	3.09-28	2.97-26	6.45-25	5.95-24	3.21-23
8.509+00	1.457+03	1.67-31	3.09-28	2.97-26	6.45-25	5.95-24	3.21-23
8.511+00	1.457+03	5.75-23	8.17-22	3.98-21	1.13-20	2.38-20	4.12-20
9.000+00	1.378+03	5.75-23	8.17-22	3.98-21	1.13-20	2.38-20	4.12-20
9.500+00	1.305+03	5.75-23	8.17-22	3.98-21	1.13-20	2.38-20	4.12-20
9.999+00	1.240+03	5.75-23	8.17-22	3.98-21	1.13-20	2.38-20	4.12-20
1.000+01	1.240+03	7.08-20	2.39-19	4.92-19	7.92-19	1.11-18	1.42-18
1.050+01	1.181+03	7.08-20	2.39-19	4.92-19	7.92-19	1.11-18	1.42-18
1.100+01	1.127+03	7.08-20	2.39-19	4.92-19	7.92-19	1.11-18	1.42-18
1.126+01	1.101+03	7.08-20	2.39-19	4.92-19	7.92-19	1.11-18	1.42-18
1.126+01	1.101+03	1.10-17	1.11-17	1.12-17	1.13-17	1.14-17	1.15-17
1.200+01	1.033+03	1.10-17	1.11-17	1.12-17	1.13-17	1.14-17	1.15-17
1.300+01	9.538+02	1.10-17	1.11-17	1.12-17	1.13-17	1.14-17	1.15-17
1.400+01	8.857+02	1.09-17	1.10-17	1.11-17	1.12-17	1.13-17	1.14-17
1.500+01	8.267+02	1.05-17	1.06-17	1.07-17	1.08-17	1.09-17	1.10-17
1.600+01	7.750+02	1.01-17	1.01-17	1.02-17	1.04-17	1.05-17	1.06-17
1.700+01	7.294+02	9.64-18	9.72-18	9.83-18	9.96-18	1.01-17	1.02-17
1.800+01	6.889+02	9.22-18	9.29-18	9.41-18	9.55-18	9.69-18	9.83-18
1.900+01	6.526+02	8.79-18	8.87-18	8.99-18	9.14-18	9.29-18	9.44-18
2.000+01	6.200+02	8.36-18	8.45-18	8.58-18	8.73-18	8.89-18	9.05-18

LOCKHEED PALO ALTO RESEARCH LABORATORY
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ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 9000	T(DEG-K) 10000	T(DEG-K) 11000	T(DEG-K) 12000	T(DEG-K) 13000	T(DEG-K) 14000
2.000-01	6.200+04	5.45-20	2.52-19	8.92-19	2.57-18	6.35-18	1.38-17
5.000-01	2.480+04	4.50-21	2.00-20	6.86-20	1.93-19	4.55-19	9.95-19
1.000+00	1.240+04	8.55-22	3.57-21	1.16-20	3.12-20	7.25-20	1.50-19
1.500+00	8.267+03	3.84-22	1.50-21	4.63-21	1.19-20	2.67-20	5.36-20
2.000+00	6.200+03	2.48-22	9.09-22	2.66-21	6.55-21	1.41-20	2.75-20
2.500+00	4.960+03	2.01-22	6.91-22	1.92-21	4.52-21	9.39-21	1.77-20
3.000+00	4.133+03	1.97-22	6.35-22	1.67-21	3.77-21	7.55-21	1.38-20
3.500+00	3.543+03	2.32-22	7.01-22	1.75-21	3.78-21	7.29-21	1.29-20
4.000+00	3.100+03	2.42-22	7.05-22	1.71-21	3.60-21	6.80-21	1.18-20
4.500+00	2.756+03	1.98-22	5.79-22	1.40-21	2.95-21	5.58-21	9.69-21
5.000+00	2.480+03	1.75-22	5.12-22	1.24-21	2.61-21	4.94-21	8.57-21
5.500+00	2.255+03	1.61-22	4.69-22	1.14-21	2.40-21	4.53-21	7.86-21
6.000+00	2.067+03	1.50-22	4.37-22	1.06-21	2.23-21	4.22-21	7.32-21
6.500+00	1.908+03	1.40-22	4.08-22	9.87-22	2.08-21	3.93-21	6.82-21
7.000+00	1.771+03	1.30-22	3.79-22	9.17-22	1.93-21	3.65-21	6.34-21
7.500+00	1.653+03	1.21-22	3.52-22	8.52-22	1.79-21	3.39-21	5.89-21
8.000+00	1.550+03	1.21-22	3.52-22	8.52-22	1.79-21	3.39-21	5.89-21
8.509+00	1.457+03	1.21-22	3.52-22	8.52-22	1.79-21	3.39-21	5.89-21
8.511+00	1.457+03	6.30-20	8.83-20	1.16-19	1.46-19	1.77-19	2.10-19
9.000+00	1.378+03	6.30-20	8.83-20	1.16-19	1.46-19	1.77-19	2.10-19
9.500+00	1.305+03	6.30-20	8.83-20	1.16-19	1.46-19	1.77-19	2.10-19
9.999+00	1.240+03	6.30-20	8.83-20	1.16-19	1.46-19	1.77-19	2.10-19
1.000+01	1.240+03	1.72-18	2.00-18	2.26-18	2.50-18	2.72-18	2.92-18
1.050+01	1.181+03	1.72-18	2.00-18	2.26-18	2.50-18	2.72-18	2.92-18
1.100+01	1.127+03	1.72-18	2.00-18	2.26-18	2.50-18	2.72-18	2.92-18
1.126+01	1.101+03	1.72-18	2.00-18	2.26-18	2.50-18	2.72-18	2.92-18
1.126+01	1.101+03	1.16-17	1.17-17	1.17-17	1.18-17	1.19-17	1.19-17
1.200+01	1.033+03	1.16-17	1.17-17	1.17-17	1.18-17	1.19-17	1.19-17
1.300+01	9.538+02	1.16-17	1.17-17	1.17-17	1.18-17	1.19-17	1.19-17
1.400+01	8.857+02	1.15-17	1.16-17	1.17-17	1.17-17	1.18-17	1.18-17
1.500+01	8.267+02	1.11-17	1.12-17	1.13-17	1.14-17	1.14-17	1.15-17
1.600+01	7.750+02	1.07-17	1.08-17	1.09-17	1.10-17	1.11-17	1.11-17
1.700+01	7.294+02	1.03-17	1.05-17	1.06-17	1.06-17	1.07-17	1.08-17
1.800+01	6.889+02	9.96-18	1.01-17	1.02-17	1.03-17	1.04-17	1.04-17
1.900+01	6.526+02	9.58-18	9.70-18	9.81-18	9.91-18	9.99-18	1.01-17
2.000+01	6.200+02	9.19-18	9.32-18	9.44-18	9.55-18	9.64-18	9.72-18

LOCKHEED PALO ALTO RESEARCH LABORATORY
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Table 4-1 (cont.)

EFFECTIVE CROSS SECTION OF NEUTRAL CARBON, CI (SQ. CM.)

ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 15000	T(DEG-K) 16000	T(DEG-K) 17000	T(DEG-K) 18000	T(DEG-K) 19000	T(DEG-K) 20000
2.000-01	6.200+04	2.73-17	4.98-17	8.48-17	1.37-16	2.10-16	3.10-16
5.000-01	2.480+04	1.93-18	3.47-18	5.83-18	9.29-18	1.41-17	2.07-17
1.000+00	1.240+04	2.84-19	4.97-19	8.18-19	1.28-18	1.91-18	2.75-18
1.500+00	8.267+03	9.84-20	1.68-19	2.71-19	4.16-19	6.12-19	8.68-19
2.000+00	6.200+03	4.91-20	8.20-20	1.29-19	1.95-19	2.81-19	3.93-19
2.500+00	4.960+03	3.08-20	5.01-20	7.74-20	1.14-19	1.52-19	2.23-19
3.000+00	4.133+03	2.33-20	3.71-20	5.60-20	8.12-20	1.13-19	1.54-19
3.500+00	3.543+03	2.12-20	3.29-20	4.87-20	6.92-20	9.51-20	1.27-19
4.000+00	3.100+03	1.91-20	2.93-20	4.28-20	6.03-20	8.20-20	1.08-19
4.500+00	2.756+03	1.57-20	2.41-20	3.52-20	4.95-20	6.73-20	8.90-20
5.000+00	2.480+03	1.39-20	2.13-20	3.11-20	4.37-20	5.95-20	7.87-20
5.500+00	2.255+03	1.27-20	1.95-20	2.85-20	4.01-20	5.46-20	7.22-20
6.000+00	2.067+03	1.19-20	1.82-20	2.65-20	3.73-20	5.08-20	6.72-20
6.500+00	1.908+03	1.11-20	1.69-20	2.48-20	3.48-20	4.74-20	6.27-20
7.000+00	1.771+03	1.03-20	1.57-20	2.30-20	3.23-20	4.40-20	5.82-20
7.500+00	1.653+03	9.54-21	1.46-20	2.14-20	3.00-20	4.09-20	5.41-20
8.000+00	1.550+03	9.54-21	1.46-20	2.14-20	3.00-20	4.09-20	5.41-20
8.509+00	1.457+03	9.54-21	1.46-20	2.14-20	3.00-20	4.09-20	5.41-20
8.511+00	1.457+03	2.43-19	2.77-19	3.12-19	3.48-19	3.85-19	4.23-19
9.000+00	1.378+03	2.43-19	2.77-19	3.12-19	3.48-19	3.85-19	4.23-19
9.500+00	1.305+03	2.43-19	2.77-19	3.12-19	3.48-19	3.85-19	4.23-19
9.999+00	1.240+03	2.43-19	2.77-19	3.12-19	3.48-19	3.85-19	4.23-19
1.000+01	1.240+03	3.10-18	3.26-18	3.42-18	3.56-18	3.69-18	3.81-18
1.050+01	1.181+03	3.10-18	3.26-18	3.42-18	3.56-18	3.69-18	3.81-18
1.100+01	1.127+03	3.10-18	3.26-18	3.42-18	3.56-18	3.69-18	3.81-18
1.126+01	1.101+03	3.10-18	3.26-18	3.42-18	3.56-18	3.69-18	3.81-18
1.126+01	1.101+03	1.19-17	1.20-17	1.20-17	1.20-17	1.20-17	1.20-17
1.200+01	1.033+03	1.19-17	1.20-17	1.20-17	1.20-17	1.20-17	1.20-17
1.300+01	9.538+02	1.19-17	1.20-17	1.20-17	1.20-17	1.20-17	1.20-17
1.400+01	8.857+02	1.19-17	1.19-17	1.19-17	1.19-17	1.19-17	1.19-17
1.500+01	8.267+02	1.15-17	1.15-17	1.16-17	1.16-17	1.16-17	1.16-17
1.600+01	7.750+02	1.12-17	1.12-17	1.12-17	1.13-17	1.13-17	1.13-17
1.700+01	7.294+02	1.08-17	1.09-17	1.09-17	1.09-17	1.10-17	1.10-17
1.800+01	6.889+02	1.05-17	1.05-17	1.06-17	1.06-17	1.06-17	1.07-17
1.900+01	6.526+02	1.01-17	1.02-17	1.02-17	1.03-17	1.03-17	1.03-17
2.000+01	6.200+02	9.79-18	9.85-18	9.90-18	9.95-18	9.99-18	1.00-17

ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 21000	T(DEG-K) 22000	T(DEG-K) 23000	T(DEG-K) 24000
2.000-01	6.200+04	4.42-16	6.11-16	8.23-16	1.08-15
5.000-01	2.480+04	2.92-17	4.01-17	5.37-17	7.02-17
1.000+00	1.240+04	3.84-18	5.20-18	6.89-18	8.92-18
1.500+00	8.267+03	1.19-18	1.60-18	2.09-18	2.68-18
2.000+00	6.200+03	5.33-19	7.05-19	9.11-19	1.15-18
2.500+00	4.960+03	2.99-19	3.90-19	4.99-19	6.26-19
3.000+00	4.133+03	2.03-19	2.61-19	3.30-19	4.10-19
3.500+00	3.543+03	1.65-19	2.10-19	2.63-19	3.22-19
4.000+00	3.100+03	1.40-19	1.77-19	2.20-19	2.68-19
4.500+00	2.756+03	1.15-19	1.45-19	1.80-19	2.20-19
5.000+00	2.480+03	1.02-19	1.28-19	1.59-19	1.95-19
5.500+00	2.255+03	9.32-20	1.18-19	1.46-19	1.79-19
6.000+00	2.067+03	8.68-20	1.10-19	1.36-19	1.66-19
6.500+00	1.908+03	8.09-20	1.02-19	1.27-19	1.55-19
7.000+00	1.771+03	7.52-20	9.50-20	1.18-19	1.44-19
7.500+00	1.653+03	6.98-20	8.83-20	1.10-19	1.34-19
8.000+00	1.550+03	6.98-20	8.83-20	1.10-19	1.34-19
8.509+00	1.457+03	6.98-20	8.83-20	1.10-19	1.34-19
8.511+00	1.457+03	4.63-19	5.05-19	5.48-19	5.93-19
9.000+00	1.378+03	4.63-19	5.05-19	5.48-19	5.93-19
9.500+00	1.305+03	4.63-19	5.05-19	5.48-19	5.93-19
9.999+00	1.240+03	4.63-19	5.05-19	5.48-19	5.93-19
1.000+01	1.240+03	3.93-18	4.04-18	4.14-18	4.24-18
1.050+01	1.181+03	3.93-18	4.04-18	4.14-18	4.24-18
1.100+01	1.127+03	3.93-18	4.04-18	4.14-18	4.24-18
1.126+01	1.101+03	3.93-18	4.04-18	4.14-18	4.24-18
1.126+01	1.101+03	1.20-17	1.20-17	1.21-17	1.21-17
1.200+01	1.033+03	1.20-17	1.20-17	1.21-17	1.21-17
1.300+01	9.538+02	1.20-17	1.20-17	1.21-17	1.21-17
1.400+01	8.857+02	1.20-17	1.20-17	1.20-17	1.20-17
1.500+01	8.267+02	1.16-17	1.17-17	1.17-17	1.17-17
1.600+01	7.750+02	1.13-17	1.13-17	1.14-17	1.14-17
1.700+01	7.294+02	1.10-17	1.10-17	1.11-17	1.11-17
1.800+01	6.889+02	1.07-17	1.07-17	1.07-17	1.08-17
1.900+01	6.526+02	1.04-17	1.04-17	1.04-17	1.05-17
2.000+01	6.200+02	1.01-17	1.01-17	1.01-17	1.02-17

LOCKHEED PALO ALTO RESEARCH LABORATORY
LOCKHEED MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

Table 4-2

EFFECTIVE CROSS SECTION OF SINGLY IONIZED CARBON, CII (SQ.CM.)

ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 3000	T(DEG-K) 4000	T(DEG-K) 5000	T(DEG-K) 6000	T(DEG-K) 7000	T(DEG-K) 8000
2.000-01	6.200+04	0.00	0.C0	0.00	2.90-34	2.71-31	4.67-29
1.000+00	1.240+04	0.00	0.00	0.00	1.03-35	7.71-33	1.12-30
2.000+00	6.200+03	0.00	0.00	0.00	8.30-36	4.72-33	5.60-31
3.000+00	4.133+03	0.00	0.C0	3.37-39	1.59-35	6.88-33	6.63-31
4.000+00	3.100+03	0.00	0.C0	1.36-38	4.37-35	1.43-32	1.12-30
5.000+00	2.480+03	0.00	0.C0	6.70-38	1.46-34	3.63-32	2.31-30
6.000+00	2.067+03	0.00	0.C0	3.74-37	5.53-34	1.04-31	5.39-30
7.000+00	1.771+03	0.00	0.C0	2.27-36	2.29-33	3.27-31	1.37-29
8.000+00	1.550+03	0.00	0.C0	1.48-35	1.01-32	1.09-30	3.74-29
9.000+00	1.378+03	0.00	1.C7-38	1.01-34	4.70-32	3.86-30	1.07-28
1.000+01	1.240+03	0.00	1.36-37	7.25-34	2.28-31	1.42-29	3.22-28
1.100+01	1.127+03	0.00	1.81-36	5.38-33	1.15-30	5.45-29	1.00-27
1.200+01	1.033+03	0.00	2.48-35	4.13-32	6.01-30	2.16-28	3.22-27
1.300+01	9.538+02	4.28-39	3.50-34	3.27-31	3.23-29	8.78-28	1.07-26
1.400+01	8.857+02	1.64-37	5.C9-33	2.66-30	1.78-28	3.68-27	3.63-26
1.500+01	8.267+02	6.42-36	7.60-32	2.22-29	1.01-27	1.58-26	1.27-25
1.600+01	7.750+02	7.35-36	8.C5-32	2.24-29	9.91-28	1.52-26	1.20-25
1.700+01	7.294+02	6.31-36	6.91-32	1.93-29	8.51-28	1.30-26	1.03-25
1.800+01	6.889+02	5.53-36	6.C6-32	1.69-29	7.46-28	1.14-26	9.01-26
1.900+01	6.526+02	4.94-36	5.40-32	1.51-29	6.66-28	1.02-26	8.04-26
1.910+01	6.492+02	1.17-26	2.C7-24	4.61-23	3.66-22	1.50-21	4.85-21
2.000+01	6.200+02	1.17-26	2.C7-24	4.61-23	3.66-22	1.50-21	4.85-21

LOCKHEED PALO ALTO RESEARCH LABORATORY
LOCKHEED MISSILES & SPACE COMPANY
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ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 9000	T(DEG-K) 10000	T(DEG-K) 11000	T(DEG-K) 12000	T(DEG-K) 13000	T(DEG-K) 14000
2.000-01	6.200+04	2.59-27	6.53-26	9.23-25	8.45-24	5.54-23	2.79-22
1.000+00	1.240+04	5.50-29	1.25-27	1.62-26	1.38-25	8.55-25	4.09-24
2.000+00	6.200+03	2.33-29	4.65-28	5.43-27	4.25-26	2.44-25	1.09-24
3.000+00	4.133+03	2.35-29	4.12-28	4.33-27	3.10-26	1.55-25	6.96-25
4.000+00	3.100+03	3.38-29	5.21-28	4.93-27	3.23-26	1.50-25	6.32-25
5.000+00	2.480+03	5.92-29	8.03-28	6.84-27	4.11-26	1.88-25	6.99-25
6.000+00	2.067+03	1.18-28	1.40-27	1.07-26	5.91-26	2.52-25	8.76-25
7.000+00	1.771+03	2.55-28	2.68-27	1.85-26	9.29-26	3.57-25	1.20-24
8.000+00	1.550+03	5.92-28	5.45-27	3.38-26	1.56-25	5.73-25	1.76-24
9.000+00	1.378+03	1.45-27	1.17-26	6.54-26	2.76-25	9.41-25	2.70-24
1.000+01	1.240+03	3.69-27	2.62-26	1.32-25	5.10-25	1.51-24	4.35-24
1.100+01	1.127+03	9.76-27	6.11-26	2.76-25	9.78-25	2.87-24	7.27-24
1.200+01	1.033+03	2.67-26	1.47-25	5.97-25	1.94-24	5.28-24	1.25-23
1.300+01	9.538+02	7.53-26	3.64-25	1.33-24	3.96-24	1.00-23	2.23-23
1.400+01	8.857+02	2.18-25	9.27-25	3.06-24	8.32-24	1.95-23	4.08-23
1.500+01	8.267+02	6.50-25	2.43-24	7.19-24	1.79-23	3.91-23	7.67-23
1.600+01	7.750+02	6.05-25	2.24-24	6.57-24	1.63-23	3.53-23	6.88-23
1.700+01	7.294+02	5.20-25	1.92-24	5.65-24	1.40-23	3.03-23	5.91-23
1.800+01	6.889+02	4.55-25	1.68-24	4.95-24	1.23-23	2.65-23	5.18-23
1.900+01	6.526+02	4.06-25	1.50-24	4.42-24	1.09-23	2.37-23	4.62-23
1.910+01	6.492+02	1.15-20	2.28-20	4.00-20	6.38-20	9.45-20	1.32-19
2.000+01	6.200+02	1.15-20	2.28-20	4.00-20	6.38-20	9.45-20	1.32-19

Table 4-2 (cont.)

EFFECTIVE CROSS SECTION OF SINGLY IONIZED CARBON, CII (SQ.CM.)

ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 15000	T(DEG-K) 16000	T(DEG-K) 17000	T(DEG-K) 18000	T(DEG-K) 19000	T(DEG-K) 20000
2.000-01	6.200+04	1.14-21	3.92-21	1.17-20	3.10-20	7.43-20	1.64-19
1.000+00	1.240+04	1.60-23	5.29-23	1.52-22	3.92-22	9.15-22	1.97-21
2.000+00	6.200+03	4.04-24	1.27-23	3.52-23	8.72-23	1.97-22	4.10-22
3.000+00	4.133+03	2.43-24	7.30-24	1.93-23	4.61-23	1.01-22	2.04-22
4.000+00	3.100+03	2.09-24	5.98-24	1.52-23	3.48-23	7.34-23	1.44-22
5.000+00	2.480+03	2.19-24	5.96-24	1.45-23	3.20-23	6.53-23	1.24-22
6.000+00	2.067+03	2.60-24	6.74-24	1.57-23	3.34-23	6.58-23	1.22-22
7.000+00	1.771+03	3.36-24	8.32-24	1.86-23	3.80-23	7.25-23	1.30-22
8.000+00	1.550+03	4.65-24	1.10-23	2.35-23	4.63-23	8.52-23	1.48-22
9.000+00	1.378+03	6.79-24	1.52-23	3.12-23	5.93-23	1.06-22	1.78-22
1.000+01	1.240+03	1.03-23	2.21-23	4.34-23	7.94-23	1.37-22	2.23-22
1.100+01	1.127+03	1.63-23	3.33-23	6.27-23	1.10-22	1.83-22	2.91-22
1.200+01	1.033+03	2.67-23	5.18-23	9.35-23	1.58-22	2.55-22	3.91-22
1.300+01	9.538+02	4.49-23	8.31-23	1.44-22	2.34-22	3.64-22	5.43-22
1.400+01	8.857+02	7.77-23	1.37-22	2.27-22	3.57-22	5.36-22	7.75-22
1.500+01	8.267+02	1.38-22	2.32-22	3.68-22	5.57-22	8.09-22	1.13-21
1.600+01	7.750+02	1.23-22	2.07-22	3.27-22	4.93-22	7.13-22	9.98-22
1.700+01	7.294+02	1.06-22	1.77-22	2.81-22	4.23-22	6.13-22	8.57-22
1.800+01	6.889+02	9.29-23	1.55-22	2.46-22	3.71-22	5.37-22	7.51-22
1.900+01	6.526+02	8.29-23	1.39-22	2.19-22	3.31-22	4.79-22	6.70-22
1.910+01	6.492+02	1.76-19	2.26-19	2.81-19	3.41-19	4.04-19	4.69-19
2.000+01	6.200+02	1.76-19	2.26-19	2.81-19	3.41-19	4.04-19	4.69-19

ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 21000	T(DEG-K) 22000	T(DEG-K) 23000	T(DEG-K) 24000
2.000-01	6.200+04	3.36-19	6.46-19	1.18-18	2.04-18
1.000+00	1.240+04	3.95-21	7.44-21	1.33-20	2.27-20
2.000+00	6.200+03	8.00-22	1.47-21	2.57-21	4.30-21
3.000+00	4.133+03	3.86-22	6.92-22	1.18-21	1.93-21
4.000+00	3.100+03	2.66-22	4.65-22	7.76-22	1.24-21
5.000+00	2.480+03	2.23-22	3.80-22	6.21-22	9.74-22
6.000+00	2.067+03	2.12-22	3.53-22	5.63-22	8.64-22
7.000+00	1.771+03	2.20-22	3.57-22	5.57-22	8.38-22
8.000+00	1.550+03	2.45-22	3.87-22	5.89-22	8.68-22
9.000+00	1.378+03	2.86-22	4.41-22	6.56-22	9.47-22
1.000+01	1.240+03	3.49-22	5.25-22	7.64-22	1.08-21
1.100+01	1.127+03	4.42-22	6.49-22	9.22-22	1.28-21
1.200+01	1.033+03	5.79-22	8.28-22	1.15-21	1.56-21
1.300+01	9.538+02	7.81-22	1.09-21	1.48-21	1.96-21
1.400+01	8.857+02	1.08-21	1.47-21	1.96-21	2.54-21
1.500+01	8.267+02	1.54-21	2.05-21	2.66-21	3.38-21
1.600+01	7.750+02	1.36-21	1.79-21	2.32-21	2.95-21
1.700+01	7.294+02	1.16-21	1.54-21	2.00-21	2.53-21
1.800+01	6.889+02	1.02-21	1.35-21	1.75-21	2.22-21
1.900+01	6.526+02	9.11-22	1.21-21	1.56-21	1.98-21
1.910+01	6.492+02	5.37-19	6.06-19	6.76-19	7.47-19
2.000+01	6.200+02	5.37-19	6.06-19	6.76-19	7.46-19

Table 4-3

EFFECTIVE CROSS SECTION OF NEUTRAL NITROGEN, NI(SQ. CM)

ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 3000	T(DEG-K) 4000	T(DEG-K) 5000	T(DEG-K) 6000	T(DEG-K) 7000	T(DEG-K) 8000
2.500E-01	4.959E 04	0.	5.26E-32	2.84E-28	9.11E-26	5.77E-24	1.31E-22
5.000E-01	2.480E 04	0.	6.54E-33	3.96E-29	1.45E-26	8.64E-25	1.88E-23
7.500E-01	1.653E 04	0.	1.93E-33	2.22E-29	7.33E-27	3.96E-25	8.03E-24
1.000E 00	1.240E 04	0.	8.14E-34	2.22E-29	5.80E-27	2.85E-25	5.37E-24
2.000E 00	6.199E 03	0.	1.02E-34	2.09E-29	3.48E-27	1.33E-25	2.07E-24
3.000E 00	4.133E 03	0.	3.03E-35	3.85E-29	4.23E-27	1.24E-25	1.58E-24
4.000E 00	3.100E 03	0.	3.77E-36	1.69E-29	1.87E-27	5.48E-26	7.01E-25
5.000E 00	2.480E 03	0.	1.95E-36	7.06E-29	4.79E-27	1.05E-25	1.11E-24
6.000E 00	2.066E 03	0.	1.13E-36	6.61E-29	4.36E-27	9.29E-26	9.57E-25
7.000E 00	1.771E 03	0.	7.18E-37	7.36E-29	4.68E-27	9.59E-26	9.56E-25
8.000E 00	1.550E 03	0.	4.83E-37	8.47E-29	5.25E-27	1.05E-25	1.02E-24
9.000E 00	1.378E 03	0.	3.39E-37	9.27E-29	5.69E-27	1.12E-25	1.08E-24
9.500E 00	1.305E 03	0.	2.88E-37	4.08E-28	2.70E-26	5.36E-25	5.03E-24
1.000E 01	1.240E 03	0.	2.47E-37	4.04E-28	2.66E-26	5.29E-25	4.96E-24
1.050E 01	1.181E 03	0.	2.13E-37	4.00E-28	2.63E-26	5.22E-25	4.89E-24
1.095E 01	1.132E 03	0.	1.88E-37	3.91E-28	2.57E-26	5.09E-25	4.77E-24
1.100E 01	1.127E 03	1.28E-23	4.04E-22	3.19E-21	1.25E-20	3.28E-20	6.66E-20
1.150E 01	1.078E 03	1.27E-23	4.02E-22	3.17E-21	1.25E-20	3.26E-20	6.62E-20
1.215E 01	1.020E 03	1.25E-23	3.95E-22	3.12E-21	1.22E-20	3.21E-20	6.51E-20
1.220E 01	1.016E 03	1.58E-21	1.61E-20	6.53E-20	1.66E-19	3.23E-19	5.25E-19
1.250E 01	9.918E 02	1.59E-21	1.62E-20	6.56E-20	1.67E-19	3.24E-19	5.27E-19
1.300E 01	9.537E 02	1.61E-21	1.65E-20	6.72E-20	1.72E-19	3.37E-19	5.53E-19
1.350E 01	9.184E 02	1.60E-21	1.63E-20	6.66E-20	1.70E-19	3.33E-19	5.46E-19
1.400E 01	8.856E 02	1.57E-21	1.60E-20	6.54E-20	1.67E-19	3.27E-19	5.36E-19
1.405E 01	8.824E 02	2.59E-21	2.62E-20	1.06E-19	2.67E-19	5.16E-19	8.35E-19
1.450E 01	8.550E 02	2.58E-21	2.61E-20	1.05E-19	2.66E-19	5.13E-19	8.30E-19
1.455E 01	8.521E 02	7.86E-18	7.86E-18	7.89E-18	7.92E-18	7.99E-18	8.06E-18
1.500E 01	8.265E 02	8.10E-18	8.09E-18	8.12E-18	8.15E-18	8.21E-18	8.27E-18
1.600E 01	7.749E 02	8.39E-18	8.39E-18	8.40E-18	8.43E-18	8.47E-18	8.52E-18
1.700E 01	7.293E 02	8.27E-18	8.26E-18	8.28E-18	8.29E-18	8.33E-18	8.37E-18
1.800E 01	6.888E 02	7.98E-18	7.98E-18	7.99E-18	8.01E-18	8.04E-18	8.08E-18
2.000E 01	6.199E 02	7.39E-18	7.39E-18	7.40E-18	7.41E-18	7.44E-18	7.47E-18

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ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 9000	T(DEG-K) 10000	T(DEG-K) 11000	T(DEG-K) 12000	T(DEG-K) 13000	T(DEG-K) 14000
2.500E-01	4.959E 04	1.50E-21	1.06E-20	5.65E-20	2.01E-19	6.74E-19	1.66E-18
5.000E-01	2.480E 04	2.08E-22	1.43E-21	7.48E-21	2.63E-20	8.66E-20	2.11E-19
7.500E-01	1.653E 04	8.41E-23	5.54E-22	2.75E-21	9.49E-21	3.02E-20	7.26E-20
1.000E 00	1.240E 04	5.32E-23	3.35E-22	1.58E-21	5.35E-21	1.64E-20	3.89E-20
2.000E 00	6.199E 03	1.76E-23	9.83E-23	4.14E-22	1.31E-21	3.66E-21	8.42E-21
3.000E 00	4.133E 03	1.16E-23	5.77E-23	2.20E-22	6.56E-22	1.71E-21	3.78E-21
4.000E 00	3.100E 03	5.15E-24	2.56E-23	9.77E-23	2.90E-22	7.56E-22	1.67E-21
5.000E 00	2.480E 03	7.12E-24	3.21E-23	1.12E-22	3.15E-22	7.71E-22	1.64E-21
6.000E 00	2.066E 03	5.93E-24	2.66E-23	9.17E-23	2.54E-22	6.12E-22	1.29E-21
7.000E 00	1.771E 03	5.79E-24	2.53E-23	8.53E-23	2.32E-22	5.51E-22	1.15E-21
8.000E 00	1.550E 03	6.09E-24	2.60E-23	8.62E-23	2.32E-22	5.42E-22	1.12E-21
9.000E 00	1.378E 03	6.37E-24	2.69E-23	8.82E-23	2.35E-22	5.45E-22	1.12E-21
9.500E 00	1.305E 03	2.85E-23	1.13E-22	3.49E-22	8.84E-22	1.94E-21	3.77E-21
1.000E 01	1.240E 03	2.81E-23	1.12E-22	3.44E-22	8.72E-22	1.91E-21	3.72E-21
1.050E 01	1.181E 03	2.77E-23	1.10E-22	3.39E-22	8.60E-22	1.89E-21	3.67E-21
1.095E 01	1.132E 03	2.70E-23	1.07E-22	3.31E-22	8.38E-22	1.84E-21	3.58E-21
1.100E 01	1.127E 03	1.14E-19	1.73E-19	2.43E-19	3.15E-19	3.92E-19	4.70E-19
1.150E 01	1.078E 03	1.13E-19	1.72E-19	2.42E-19	3.13E-19	3.90E-19	4.67E-19
1.215E 01	1.020E 03	1.11E-19	1.69E-19	2.38E-19	3.08E-19	3.83E-19	4.60E-19
1.220E 01	1.016E 03	7.59E-19	1.01E-18	1.28E-18	1.53E-18	1.77E-18	2.00E-18
1.250E 01	9.918E 02	7.61E-19	1.02E-18	1.28E-18	1.53E-18	1.77E-18	2.00E-18
1.300E 01	9.537E 02	8.05E-19	1.08E-18	1.37E-18	1.64E-18	1.91E-18	2.17E-18
1.350E 01	9.184E 02	7.95E-19	1.07E-18	1.35E-18	1.62E-18	1.88E-18	2.14E-18
1.400E 01	8.856E 02	7.80E-19	1.05E-18	1.33E-18	1.59E-18	1.85E-18	2.09E-18
1.405E 01	8.824E 02	1.20E-18	1.60E-18	2.00E-18	2.38E-18	2.74E-18	3.09E-18
1.450E 01	8.550E 02	1.19E-18	1.58E-18	1.99E-18	2.36E-18	2.72E-18	3.07E-18
1.455E 01	8.521E 02	8.15E-18	8.24E-18	8.38E-18	8.41E-18	8.48E-18	8.54E-18
1.500E 01	8.265E 02	8.34E-18	8.43E-18	8.56E-18	8.57E-18	8.62E-18	8.67E-18
1.600E 01	7.749E 02	8.58E-18	8.65E-18	8.76E-18	8.76E-18	8.80E-18	8.84E-18
1.700E 01	7.293E 02	8.42E-18	8.47E-18	8.57E-18	8.56E-18	8.59E-18	8.62E-18
1.800E 01	6.888E 02	8.12E-18	8.17E-18	8.26E-18	8.25E-18	8.27E-18	8.29E-18
2.000E 01	6.199E 02	7.50E-18	7.54E-18	7.63E-18	7.61E-18	7.63E-18	7.65E-18

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Table 4-3 (cont.)

EFFECTIVE CROSS SECTION OF NEUTRAL NITROGEN, NI(SQ. CM)

ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 15000	T(DEG-K) 16000	T(DEG-K) 17000	T(DEG-K) 18000	T(DEG-K) 19000	T(DEG-K) 20000
2.500E-01	4.959E 04	3.61E-18	8.03E-18	1.53E-17	2.67E-17	4.38E-17	6.84E-17
5.000E-01	2.480E 04	4.57E-19	1.00E-18	1.89E-18	3.28E-18	5.34E-18	8.31E-18
7.500E-01	1.653E 04	1.56E-19	3.34E-19	6.21E-19	1.07E-18	1.72E-18	2.66E-18
1.000E 00	1.240E 04	8.27E-20	1.72E-19	3.15E-19	5.34E-19	8.50E-19	1.29E-18
2.000E 00	6.199E 03	1.73E-20	3.39E-20	5.98E-20	9.81E-20	1.51E-19	2.23E-19
3.000E 00	4.133E 03	7.51E-21	1.41E-20	2.41E-20	3.85E-20	5.81E-20	8.37E-20
4.000E 00	3.100E 03	3.31E-21	6.19E-21	1.06E-20	1.69E-20	2.54E-20	3.65E-20
5.000E 00	2.480E 03	3.14E-21	5.63E-21	9.32E-21	1.44E-20	2.12E-20	2.96E-20
6.000E 00	2.066E 03	2.45E-21	4.33E-21	7.11E-21	1.09E-20	1.59E-20	2.20E-20
7.000E 00	1.771E 03	2.16E-21	3.78E-21	6.14E-21	9.35E-21	1.35E-20	1.85E-20
8.000E 00	1.550E 03	2.09E-21	3.60E-21	5.81E-21	8.76E-21	1.25E-20	1.71E-20
9.000E 00	1.378E 03	2.07E-21	3.55E-21	5.69E-21	8.53E-21	1.21E-20	1.64E-20
9.500E 00	1.305E 03	6.67E-21	1.09E-20	1.68E-20	2.41E-20	3.30E-20	4.31E-20
1.000E 01	1.240E 03	6.58E-21	1.08E-20	1.65E-20	2.38E-20	3.25E-20	4.25E-20
1.050E 01	1.181E 03	6.50E-21	1.06E-20	1.63E-20	2.35E-20	3.22E-20	4.20E-20
1.095E 01	1.132E 03	6.33E-21	1.04E-20	1.59E-20	2.29E-20	3.13E-20	4.09E-20
1.100E 01	1.127E 03	5.46E-19	6.16E-19	6.81E-19	7.34E-19	7.75E-19	8.02E-19
1.150E 01	1.078E 03	5.42E-19	6.12E-19	6.76E-19	7.29E-19	7.70E-19	7.96E-19
1.215E 01	1.020E 03	5.33E-19	6.02E-19	6.65E-19	7.16E-19	7.56E-19	7.81E-19
1.220E 01	1.016E 03	2.20E-18	2.36E-18	2.50E-18	2.59E-18	2.63E-18	2.64E-18
1.250E 01	9.918E 02	2.20E-18	2.36E-18	2.50E-18	2.59E-18	2.63E-18	2.63E-18
1.300E 01	9.537E 02	2.39E-18	2.57E-18	2.73E-18	2.84E-18	2.89E-18	2.90E-18
1.350E 01	9.184E 02	2.36E-18	2.54E-18	2.69E-18	2.79E-18	2.85E-18	2.85E-18
1.400E 01	8.856E 02	2.31E-18	2.49E-18	2.64E-18	2.74E-18	2.79E-18	2.79E-18
1.405E 01	8.824E 02	3.39E-18	3.63E-18	3.83E-18	3.95E-18	4.01E-18	3.99E-18
1.450E 01	8.550E 02	3.36E-18	3.60E-18	3.79E-18	3.92E-18	3.97E-18	3.96E-18
1.455E 01	8.521E 02	8.56E-18	8.51E-18	8.41E-18	8.23E-18	7.97E-18	7.61E-18
1.500E 01	8.265E 02	8.68E-18	8.62E-18	8.51E-18	8.32E-18	8.04E-18	7.68E-18
1.600E 01	7.749E 02	8.84E-18	8.76E-18	8.65E-18	8.45E-18	8.17E-18	7.80E-18
1.700E 01	7.293E 02	8.61E-18	8.53E-18	8.41E-18	8.20E-18	7.93E-18	7.56E-18
1.800E 01	6.888E 02	8.28E-18	8.20E-18	8.08E-18	7.88E-18	7.62E-18	7.26E-18
2.000E 01	6.199E 02	7.64E-18	7.56E-18	7.45E-18	7.27E-18	7.02E-18	6.69E-18

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ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 21000	T(DEG-K) 22000	T(DEG-K) 23000	T(DEG-K) 24000
2.500E-01	4.959E 04	9.77E-17	1.35E-16	1.79E-16	2.27E-16
5.000E-01	2.480E 04	1.18E-17	1.62E-17	2.13E-17	2.71E-17
7.500E-01	1.653E 04	3.75E-18	5.12E-18	6.70E-18	8.45E-18
1.000E 00	1.240E 04	1.81E-18	2.44E-18	3.17E-18	3.96E-18
2.000E 00	6.199E 03	3.06E-19	4.04E-19	5.14E-19	6.32E-19
3.000E 00	4.133E 03	1.13E-19	1.47E-19	1.85E-19	2.24E-19
4.000E 00	3.100E 03	4.92E-20	6.40E-20	8.01E-20	9.70E-20
5.000E 00	2.480E 03	3.92E-20	4.99E-20	6.14E-20	7.30E-20
6.000E 00	2.066E 03	2.89E-20	3.66E-20	4.47E-20	5.28E-20
7.000E 00	1.771E 03	2.42E-20	3.04E-20	3.69E-20	4.32E-20
8.000E 00	1.550E 03	2.21E-20	2.76E-20	3.33E-20	3.88E-20
9.000E 00	1.378E 03	2.12E-20	2.64E-20	3.16E-20	3.67E-20
9.500E 00	1.305E 03	5.38E-20	6.48E-20	7.55E-20	8.52E-20
1.000E 01	1.240E 03	5.30E-20	6.38E-20	7.42E-20	8.37E-20
1.050E 01	1.181E 03	5.24E-20	6.32E-20	7.35E-20	8.30E-20
1.095E 01	1.132E 03	5.11E-20	6.15E-20	7.16E-20	8.07E-20
1.100E 01	1.127E 03	8.14E-19	8.11E-19	7.95E-19	7.70E-19
1.150E 01	1.078E 03	8.08E-19	8.04E-19	7.88E-19	7.63E-19
1.215E 01	1.020E 03	7.92E-19	7.88E-19	7.72E-19	7.47E-19
1.220E 01	1.016E 03	2.59E-18	2.50E-18	2.38E-18	2.23E-18
1.250E 01	9.918E 02	2.59E-18	2.49E-18	2.37E-18	2.23E-18
1.300E 01	9.537E 02	2.85E-18	2.75E-18	2.62E-18	2.46E-18
1.350E 01	9.184E 02	2.80E-18	2.70E-18	2.58E-18	2.42E-18
1.400E 01	8.856E 02	2.75E-18	2.65E-18	2.52E-18	2.37E-18
1.405E 01	8.824E 02	3.91E-18	3.75E-18	3.56E-18	3.33E-18
1.450E 01	8.550E 02	3.87E-18	3.72E-18	3.53E-18	3.30E-18
1.455E 01	8.521E 02	7.18E-18	6.69E-18	6.17E-18	5.63E-18
1.500E 01	8.265E 02	7.24E-18	6.74E-18	6.21E-18	5.66E-18
1.600E 01	7.749E 02	7.35E-18	6.84E-18	6.30E-18	5.74E-18
1.700E 01	7.293E 02	7.12E-18	6.62E-18	6.10E-18	5.55E-18
1.800E 01	6.888E 02	6.84E-18	6.36E-18	5.86E-18	5.33E-18
2.000E 01	6.199E 02	6.30E-18	5.86E-18	5.40E-18	4.91E-18

LOCKHEED PALO ALTO RESEARCH LABORATORY
LOCKHEED MISSILES & SPACE COMPANY
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Table 4-4

EFFECTIVE CROSS SECTION OF THE NITROGEN ION, NII(SQ.CM)

ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 3000	T(DEG-K) 4000	T(DEG-K) 5000	T(DEG-K) 6000	T(DEG-K) 7000	T(DEG-K) 8000
2.500E-01	4.959E 04	0.	0.	0.	0.	0.	0.
5.000E-01	2.480E 04	0.	0.	0.	0.	0.	0.
7.500E-01	1.653E 04	0.	0.	0.	0.	0.	0.
1.000E 00	1.240E 04	0.	0.	0.	0.	0.	0.
1.500E 00	8.265E 03	0.	0.	0.	0.	0.	0.
2.000E 00	6.199E 03	0.	0.	0.	0.	0.	1.31E-34
2.500E 00	4.959E 03	0.	0.	0.	0.	0.	1.04E-33
3.000E 00	4.133E 03	0.	0.	0.	0.	0.	5.80E-34
3.500E 00	3.542E 03	0.	0.	0.	0.	0.	3.53E-34
4.000E 00	3.100E 03	0.	0.	0.	0.	0.	5.51E-33
5.000E 00	2.480E 03	0.	0.	0.	0.	0.	2.93E-33
6.000E 00	2.066E 03	0.	0.	0.	0.	0.	1.77E-33
6.500E 00	1.907E 03	0.	0.	0.	0.	0.	5.81E-32
7.000E 00	1.771E 03	0.	0.	0.	0.	0.	4.50E-32
7.500E 00	1.653E 03	0.	0.	0.	0.	0.	3.54E-32
7.660E 00	1.619E 03	0.	0.	0.	0.	0.	3.29E-32
8.000E 00	1.550E 03	0.	0.	0.	0.	0.	2.83E-32
8.500E 00	1.459E 03	0.	0.	0.	0.	0.	2.29E-32
8.650E 00	1.433E 03	0.	0.	0.	0.	0.	2.15E-32
9.000E 00	1.378E 03	0.	0.	0.	0.	3.63E-33	2.93E-31
9.500E 00	1.305E 03	0.	0.	0.	0.	3.67E-33	2.93E-31
1.000E 01	1.240E 03	0.	0.	0.	0.	3.68E-33	2.91E-31
1.050E 01	1.181E 03	0.	0.	0.	0.	3.68E-33	2.89E-31
1.100E 01	1.127E 03	0.	0.	0.	0.	3.66E-33	2.86E-31
1.114E 01	1.113E 03	0.	0.	0.	0.	2.32E-31	1.07E-29
1.150E 01	1.078E 03	0.	0.	0.	0.	2.13E-31	9.81E-30
1.200E 01	1.033E 03	0.	0.	0.	0.	1.90E-31	8.75E-30
1.400E 01	8.856E 02	0.	0.	0.	0.	1.26E-31	5.85E-30
1.600E 01	7.749E 02	0.	0.	0.	0.	9.12E-32	4.25E-30
1.700E 01	7.293E 02	0.	0.	0.	0.	7.98E-32	3.73E-30
1.740E 01	7.101E 02	0.	0.	0.	0.	7.52E-32	3.52E-30
2.000E 01	6.199E 02	0.	0.	0.	0.	6.10E-32	2.89E-30

LOCKHEED PALO ALTO RESEARCH LABORATORY
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ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 9000	T(DEG-K) 10000	T(DEG-K) 11000	T(DEG-K) 12000	T(DEG-K) 13000	T(DEG-K) 14000
2.500E-01	4.959E 04	1.43E-30	7.24E-29	1.81E-27	2.67E-26	2.62E-25	1.86E-24
5.000E-01	2.480E 04	1.71E-31	8.62E-30	2.14E-28	3.14E-27	3.08E-26	2.18E-25
7.500E-01	1.653E 04	5.03E-32	2.52E-30	6.26E-29	9.15E-28	8.92E-27	6.31E-26
1.000E 00	1.240E 04	1.94E-31	7.90E-30	1.65E-28	2.07E-27	1.77E-26	1.12E-25
1.500E 00	8.265E 03	3.14E-31	1.24E-29	2.50E-28	3.05E-27	2.53E-26	1.55E-25
2.000E 00	6.199E 03	1.82E-31	7.06E-30	1.40E-28	1.69E-27	1.32E-26	8.48E-26
2.500E 00	4.959E 03	2.02E-31	7.25E-30	1.36E-28	1.57E-27	1.21E-26	7.33E-26
3.000E 00	4.133E 03	1.19E-31	4.28E-30	8.03E-29	9.27E-28	7.17E-27	4.32E-26
3.500E 00	3.542E 03	7.65E-32	2.75E-30	5.15E-29	5.94E-28	4.61E-27	2.77E-26
4.000E 00	3.100E 03	3.87E-31	1.11E-29	1.75E-28	1.74E-27	1.22E-26	6.53E-26
5.000E 00	2.480E 03	2.07E-31	5.95E-30	9.32E-29	9.29E-28	6.50E-27	3.48E-26
6.000E 00	2.066E 03	1.25E-31	3.59E-30	5.62E-29	5.60E-28	3.92E-27	2.09E-26
6.500E 00	1.907E 03	2.47E-30	5.00E-29	5.84E-28	4.57E-27	2.60E-26	1.16E-25
7.000E 00	1.771E 03	1.92E-30	3.88E-29	4.54E-28	3.56E-27	2.03E-26	9.07E-26
7.500E 00	1.653E 03	1.51E-30	3.07E-29	3.59E-28	2.81E-27	1.61E-26	7.20E-26
7.660E 00	1.619E 03	1.41E-30	2.87E-29	3.37E-28	2.66E-27	1.53E-26	6.95E-26
8.000E 00	1.550E 03	1.21E-30	2.47E-29	2.91E-28	2.30E-27	1.33E-26	6.02E-26
8.500E 00	1.459E 03	9.82E-31	2.00E-29	2.36E-28	1.87E-27	1.08E-26	4.92E-26
8.650E 00	1.433E 03	9.24E-31	1.89E-29	2.23E-28	1.77E-27	1.02E-26	4.64E-26
9.000E 00	1.378E 03	8.75E-30	1.34E-28	1.24E-27	8.07E-27	3.95E-26	1.56E-25
9.500E 00	1.305E 03	8.69E-30	1.32E-28	1.22E-27	7.88E-27	3.84E-26	1.50E-25
1.000E 01	1.240E 03	8.61E-30	1.30E-28	1.20E-27	7.70E-27	3.73E-26	1.46E-25
1.050E 01	1.181E 03	8.52E-30	1.29E-28	1.18E-27	7.53E-27	3.64E-26	1.41E-25
1.100E 01	1.127E 03	8.41E-30	1.26E-28	1.16E-27	7.36E-27	3.55E-26	1.37E-25
1.114E 01	1.113E 03	2.10E-28	2.27E-27	1.60E-26	8.16E-26	3.25E-25	1.06E-24
1.150E 01	1.078E 03	1.93E-28	2.09E-27	1.47E-26	7.53E-26	3.00E-25	9.84E-25
1.200E 01	1.033E 03	1.72E-28	1.87E-27	1.32E-26	6.76E-26	2.70E-25	8.87E-25
1.400E 01	8.856E 02	1.16E-28	1.27E-27	9.04E-27	4.65E-26	1.87E-25	6.19E-25
1.600E 01	7.749E 02	8.48E-29	9.37E-28	6.72E-27	3.49E-26	1.41E-25	4.71E-25
1.700E 01	7.293E 02	7.47E-29	8.28E-28	5.96E-27	3.11E-26	1.26E-25	4.22E-25
1.746E 01	7.101E 02	7.06E-29	7.85E-28	5.66E-27	2.96E-26	1.20E-25	4.03E-25
2.000E 01	6.199E 02	5.86E-29	6.57E-28	4.76E-27	2.50E-26	1.02E-25	3.43E-25

LOCKHEED PALO ALTO RESEARCH LABORATORY
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Table 4-4 (cont.)

EFFECTIVE CROSS SECTION OF THE NITROGEN ION, NII(SQ.CM)

ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 15000	T(DEG-K) 16000	T(DEG-K) 17000	T(DEG-K) 18000	T(DEG-K) 19000	T(DEG-K) 20000
2.500E-01	4.959E 04	1.03E-23	4.59E-23	1.73E-22	5.63E-22	1.63E-21	4.24E-21
5.000E-01	2.480E 04	1.20E-24	5.35E-24	2.01E-23	6.54E-23	1.89E-22	4.91E-22
7.500E-01	1.653E 04	3.45E-25	1.54E-24	5.75E-24	1.87E-23	5.39E-23	1.40E-22
1.000E 00	1.240E 04	5.55E-25	2.26E-24	7.82E-24	2.36E-23	6.37E-23	1.56E-22
1.500E 00	8.265E 03	7.49E-25	2.97E-24	9.99E-24	2.93E-23	7.72E-23	1.84E-22
2.000E 00	6.199E 03	4.06E-25	1.60E-24	5.35E-24	1.56E-23	3.40E-23	9.72E-23
2.500E 00	4.959E 03	3.41E-25	1.31E-24	4.31E-24	1.24E-23	2.83E-23	7.46E-23
3.000E 00	4.133E 03	2.01E-25	7.73E-25	2.53E-24	7.28E-24	1.67E-23	4.39E-23
3.500E 00	3.542E 03	1.29E-25	4.95E-25	1.62E-24	4.65E-24	1.07E-23	2.80E-23
4.000E 00	3.100E 03	2.79E-25	9.99E-25	3.08E-24	8.39E-24	1.97E-23	4.63E-23
5.000E 00	2.480E 03	1.49E-25	5.31E-25	1.64E-24	4.46E-24	1.05E-23	2.46E-23
6.000E 00	2.066E 03	8.94E-26	3.19E-25	9.83E-25	2.68E-24	6.31E-24	1.47E-23
6.500E 00	1.907E 03	4.26E-25	1.33E-24	3.65E-24	8.96E-24	1.99E-23	4.17E-23
7.000E 00	1.771E 03	3.33E-25	1.04E-24	2.86E-24	7.03E-24	1.56E-23	3.28E-23
7.500E 00	1.653E 03	2.65E-25	8.31E-25	2.28E-24	5.61E-24	1.25E-23	2.62E-23
7.660E 00	1.619E 03	2.59E-25	8.23E-25	2.29E-24	5.73E-24	1.30E-23	2.77E-23
8.000E 00	1.550E 03	2.24E-25	7.15E-25	1.99E-24	4.99E-24	1.13E-23	2.41E-23
8.500E 00	1.459E 03	1.84E-25	5.87E-25	1.64E-24	4.12E-24	9.37E-24	2.00E-23
8.650E 00	1.433E 03	1.74E-25	5.55E-25	1.55E-24	3.90E-24	8.87E-24	1.90E-23
9.000E 00	1.378E 03	5.12E-25	1.46E-24	3.73E-24	8.58E-24	1.82E-23	3.61E-23
9.500E 00	1.305E 03	4.92E-25	1.40E-24	3.54E-24	8.10E-24	1.71E-23	3.38E-23
1.000E 01	1.240E 03	4.73E-25	1.34E-24	3.37E-24	7.69E-24	1.62E-23	3.18E-23
1.050E 01	1.181E 03	4.58E-25	1.29E-24	3.24E-24	7.35E-24	1.54E-23	3.02E-23
1.100E 01	1.127E 03	4.43E-25	1.24E-24	3.11E-24	7.04E-24	1.47E-23	2.87E-23
1.114E 01	1.113E 03	2.98E-24	7.34E-24	1.64E-23	3.34E-23	6.33E-23	1.13E-22
1.150E 01	1.078E 03	2.76E-24	6.80E-24	1.52E-23	3.10E-23	5.88E-23	1.05E-22
1.200E 01	1.033E 03	2.49E-24	6.14E-24	1.37E-23	2.81E-23	5.34E-23	9.55E-23
1.400E 01	8.856E 02	1.75E-24	4.35E-24	9.78E-24	2.01E-23	3.84E-23	6.89E-23
1.600E 01	7.749E 02	1.34E-24	3.34E-24	7.56E-24	1.56E-23	2.99E-23	5.39E-23
1.700E 01	7.293E 02	1.20E-24	3.02E-24	6.83E-24	1.41E-23	2.71E-23	4.90E-23
1.746E 01	7.101E 02	1.15E-24	2.89E-24	6.55E-24	1.35E-23	2.61E-23	4.71E-23
2.000E 01	6.199E 02	9.81E-25	2.46E-24	5.59E-24	1.15E-23	2.22E-23	4.01E-23

LOCKHEED PALO ALTO RESEARCH LABORATORY
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ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 21000	T(DEG-K) 22000	T(DEG-K) 23000	T(DEG-K) 24000
2.500E-01	4.959E 04	1.01E-19	2.24E-19	4.63E-19	9.05E-19
5.000E-01	2.480E 04	1.17E-20	2.58E-20	5.33E-20	1.04E-19
7.500E-01	1.653E 04	3.34E-21	7.38E-21	1.52E-20	2.97E-20
1.000E 00	1.240E 04	1.59E-21	3.47E-21	7.09E-21	1.37E-20
1.500E 00	8.265E 03	7.66E-22	1.62E-21	3.23E-21	6.09E-21
2.000E 00	6.199E 03	3.64E-22	7.66E-22	1.52E-21	2.84E-21
2.500E 00	4.959E 03	2.38E-22	4.93E-22	9.64E-22	1.78E-21
3.000E 00	4.133E 03	1.39E-22	2.88E-22	5.62E-22	1.04E-21
3.500E 00	3.542E 03	8.82E-23	1.83E-22	3.56E-22	6.58E-22
4.000E 00	3.100E 03	1.15E-22	2.29E-22	4.31E-22	7.71E-22
5.000E 00	2.480E 03	6.06E-23	1.20E-22	2.27E-22	4.05E-22
6.000E 00	2.066E 03	3.61E-23	7.17E-23	1.35E-22	2.41E-22
6.500E 00	1.907E 03	8.47E-23	1.56E-22	2.74E-22	4.61E-22
7.000E 00	1.771E 03	6.68E-23	1.23E-22	2.17E-22	3.65E-22
7.500E 00	1.653E 03	5.35E-23	9.90E-23	1.74E-22	2.93E-22
7.660E 00	1.619E 03	5.71E-23	1.07E-22	1.91E-22	3.26E-22
8.000E 00	1.550E 03	4.99E-23	9.37E-23	1.67E-22	2.86E-22
8.500E 00	1.459E 03	4.14E-23	7.79E-23	1.39E-22	2.38E-22
8.650E 00	1.433E 03	3.93E-23	7.39E-23	1.32E-22	2.26E-22
9.000E 00	1.378E 03	6.89E-23	1.22E-22	2.08E-22	3.41E-22
9.500E 00	1.305E 03	6.40E-23	1.13E-22	1.92E-22	3.13E-22
1.000E 01	1.240E 03	6.00E-23	1.06E-22	1.78E-22	2.90E-22
1.050E 01	1.181E 03	5.66E-23	9.94E-23	1.67E-22	2.71E-22
1.100E 01	1.127E 03	5.36E-23	9.39E-23	1.57E-22	2.54E-22
1.114E 01	1.113E 03	1.92E-22	3.11E-22	4.85E-22	7.31E-22
1.150E 01	1.078E 03	1.79E-22	2.90E-22	4.51E-22	6.81E-22
1.200E 01	1.033E 03	1.62E-22	2.64E-22	4.11E-22	6.21E-22
1.400E 01	8.856E 02	1.18E-22	1.92E-22	3.00E-22	4.54E-22
1.600E 01	7.749E 02	9.22E-23	1.50E-22	2.36E-22	3.58E-22
1.700E 01	7.293E 02	8.39E-23	1.37E-22	2.15E-22	3.26E-22
1.746E 01	7.101E 02	8.07E-23	1.32E-22	2.07E-22	3.14E-22
2.000E 01	6.199E 02	6.85E-23	1.12E-22	1.75E-22	2.64E-22

LOCKHEED PALO ALTO RESEARCH LABORATORY
LOCKHEED MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

Table 4-5

EFFECTIVE CROSS SECTION OF NEUTRAL OXYGEN, OI (SQ. CM)

ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 3000	T(DEG-K) 4000	T(DEG-K) 5000	T(DEG-K) 6000	T(DEG-K) 7000	T(DEG-K) 8000
2.500E-01	4.959E 04	0.	7.24E-32	1.68E-28	2.94E-26	6.05E-24	1.14E-22
5.000E-01	2.480E 04	0.	9.37E-33	4.90E-29	7.64E-27	9.08E-25	1.65E-23
7.500E-01	1.653E 04	0.	2.83E-33	3.28E-29	5.03E-27	3.70E-25	6.39E-24
1.000E 00	1.240E 04	0.	1.21E-33	4.17E-29	5.97E-27	2.15E-25	4.53E-24
2.000E 00	6.199E 03	0.	1.56E-34	3.81E-29	4.18E-27	1.22E-25	1.71E-24
3.000E 00	4.133E 03	0.	2.25E-31	1.34E-28	9.37E-27	1.99E-25	2.01E-24
4.000E 00	3.100E 03	0.	7.70E-32	5.13E-29	3.75E-27	8.26E-26	8.59E-25
5.000E 00	2.480E 03	0.	9.79E-30	2.15E-27	7.92E-26	1.05E-24	7.41E-24
6.000E 00	2.066E 03	0.	7.87E-30	1.73E-27	6.42E-26	8.57E-25	6.10E-24
7.000E 00	1.771E 03	0.	6.67E-30	1.47E-27	5.50E-26	7.40E-25	5.32E-24
8.000E 00	1.550E 03	0.	5.83E-30	1.30E-27	4.88E-26	6.64E-25	4.83E-24
9.000E 00	1.378E 03	0.	5.47E-30	1.22E-27	4.63E-26	6.35E-25	4.66E-24
9.500E 00	1.305E 03	0.	5.38E-30	1.21E-27	4.57E-26	6.30E-25	4.64E-24
1.000E 01	1.240E 03	0.	5.30E-30	1.19E-27	4.52E-26	6.25E-25	4.63E-24
1.050E 01	1.181E 03	0.	5.22E-30	1.17E-27	4.48E-26	6.21E-25	4.61E-24
1.100E 01	1.127E 03	0.	5.15E-30	1.16E-27	4.44E-26	6.17E-25	4.60E-24
1.150E 01	1.078E 03	0.	5.08E-30	1.15E-27	4.40E-26	6.14E-25	4.59E-24
1.200E 01	1.033E 03	0.	5.01E-30	1.13E-27	4.34E-26	6.04E-25	4.50E-24
1.250E 01	9.918E 02	0.	4.99E-30	1.12E-27	4.29E-26	5.94E-25	4.39E-24
1.283E 01	9.663E 02	0.	5.02E-30	1.13E-27	4.30E-26	5.93E-25	4.36E-24
1.300E 01	9.537E 02	0.	5.04E-30	1.13E-27	4.29E-26	5.89E-25	4.32E-24
1.350E 01	9.184E 02	0.	5.08E-30	1.13E-27	4.27E-26	5.82E-25	4.23E-24
1.361E 01	9.110E 02	4.03E-18	4.02E-18	4.00E-18	3.98E-18	3.94E-18	3.90E-18
1.400E 01	8.856E 02	4.21E-18	4.21E-18	4.19E-18	4.16E-18	4.12E-18	4.08E-18
1.445E 01	8.580E 02	4.43E-18	4.43E-18	4.41E-18	4.38E-18	4.34E-18	4.29E-18
1.495E 01	8.293E 02	4.59E-18	4.58E-18	4.56E-18	4.53E-18	4.49E-18	4.44E-18
1.500E 01	8.265E 02	4.60E-18	4.60E-18	4.61E-18	4.63E-18	4.64E-18	4.66E-18
1.600E 01	7.749E 02	4.75E-18	4.76E-18	4.77E-18	4.79E-18	4.82E-18	4.85E-18
1.700E 01	7.293E 02	7.27E-18	7.28E-18	7.29E-18	7.31E-18	7.34E-18	7.36E-18
1.800E 01	6.888E 02	7.89E-18	7.90E-18	7.91E-18	7.93E-18	7.96E-18	7.98E-18
1.900E 01	6.525E 02	9.55E-18	9.56E-18	9.56E-18	9.58E-18	9.59E-18	9.60E-18
2.000E 01	6.199E 02	1.01E-17	1.01E-17	1.01E-17	1.01E-17	1.01E-17	1.01E-17

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ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 9000	T(DEG-K) 10000	T(DEG-K) 11000	T(DEG-K) 12000	T(DEG-K) 13000	T(DEG-K) 14000
2.500E-01	4.959E 04	1.14E-21	7.30E-21	4.09E-20	1.24E-19	3.77E-19	9.87E-19
5.000E-01	2.480E 04	1.60E-22	1.01E-21	5.52E-21	1.66E-20	5.01E-20	1.30E-19
7.500E-01	1.653E 04	5.95E-23	3.61E-22	1.87E-21	5.63E-21	1.66E-20	4.22E-20
1.000E 00	1.240E 04	3.96E-23	2.28E-22	1.09E-21	3.30E-21	9.42E-21	2.33E-20
2.000E 00	6.199E 03	1.29E-23	6.62E-23	2.71E-22	8.04E-22	2.15E-21	5.03E-21
3.000E 00	4.133E 03	1.29E-23	5.67E-23	1.99E-22	5.52E-22	1.36E-21	2.96E-21
4.000E 00	3.100E 03	5.61E-24	2.51E-23	8.88E-23	2.49E-22	6.13E-22	1.35E-21
5.000E 00	2.480E 03	3.46E-23	1.20E-22	3.39E-22	8.11E-22	1.72E-21	3.32E-21
6.000E 00	2.066E 03	2.86E-23	1.00E-22	2.85E-22	6.89E-22	1.47E-21	2.84E-21
7.000E 00	1.771E 03	2.52E-23	8.93E-23	2.56E-22	6.23E-22	1.34E-21	2.61E-21
8.000E 00	1.550E 03	2.32E-23	8.30E-23	2.40E-22	5.90E-22	1.28E-21	2.51E-21
9.000E 00	1.378E 03	2.26E-23	8.15E-23	2.38E-22	5.88E-22	1.28E-21	2.52E-21
9.500E 00	1.305E 03	2.26E-23	8.18E-23	2.39E-22	5.93E-22	1.29E-21	2.56E-21
1.000E 01	1.240E 03	2.26E-23	8.20E-23	2.41E-22	5.99E-22	1.31E-21	2.59E-21
1.050E 01	1.181E 03	2.26E-23	8.23E-23	2.42E-22	6.05E-22	1.32E-21	2.62E-21
1.100E 01	1.127E 03	2.26E-23	8.26E-23	2.44E-22	6.10E-22	1.34E-21	2.65E-21
1.150E 01	1.078E 03	2.26E-23	8.28E-23	2.45E-22	6.12E-22	1.34E-21	2.66E-21
1.200E 01	1.033E 03	2.21E-23	8.06E-23	2.37E-22	5.90E-22	1.29E-21	2.54E-21
1.250E 01	9.918E 02	2.14E-23	7.73E-23	2.26E-22	5.58E-22	1.21E-21	2.37E-21
1.283E 01	9.663E 02	2.12E-23	7.61E-23	2.21E-22	5.45E-22	1.18E-21	2.31E-21
1.300E 01	9.537E 02	2.09E-23	7.48E-23	2.17E-22	5.33E-22	1.15E-21	2.25E-21
1.350E 01	9.184E 02	2.02E-23	7.18E-23	2.06E-22	5.03E-22	1.08E-21	2.10E-21
1.361E 01	9.110E 02	3.85E-18	3.80E-18	3.76E-18	3.70E-18	3.66E-18	3.60E-18
1.400E 01	8.856E 02	4.03E-18	3.98E-18	3.93E-18	3.88E-18	3.83E-18	3.77E-18
1.445E 01	8.580E 02	4.25E-18	4.20E-18	4.15E-18	4.10E-18	4.05E-18	4.00E-18
1.495E 01	8.293E 02	4.39E-18	4.34E-18	4.29E-18	4.24E-18	4.19E-18	4.14E-18
1.500E 01	8.265E 02	4.69E-18	4.72E-18	4.75E-18	4.77E-18	4.80E-18	4.82E-18
1.600E 01	7.749E 02	4.89E-18	4.93E-18	4.96E-18	5.00E-18	5.04E-18	5.06E-18
1.700E 01	7.293E 02	7.40E-18	7.43E-18	7.47E-18	7.50E-18	7.53E-18	7.55E-18
1.800E 01	6.888E 02	8.02E-18	8.05E-18	8.09E-18	8.12E-18	8.15E-18	8.16E-18
1.900E 01	6.525E 02	9.63E-18	9.64E-18	9.66E-18	9.68E-18	9.69E-18	9.69E-18
2.000E 01	6.199E 02	1.01E-17	1.01E-17	1.02E-17	1.02E-17	1.02E-17	1.02E-17

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Table 4-5 (cont.)

EFFECTIVE CROSS SECTION OF NEUTRAL OXYGEN, OI (SQ. CM)

ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 15000	T(DEG-K) 16000	T(DEG-K) 17000	T(DEG-K) 18000	T(DEG-K) 19000	T(DEG-K) 20000
2.500E-01	4.959E 04	2.29E-18	4.48E-18	9.29E-18	1.67E-17	2.80E-17	4.45E-17
5.000E-01	2.480E 04	2.99E-19	5.80E-19	1.19E-18	2.13E-18	3.55E-18	5.60E-18
7.500E-01	1.653E 04	9.55E-20	1.84E-19	3.72E-19	6.58E-19	1.09E-18	1.71E-18
1.000E 00	1.240E 04	5.16E-20	9.86E-20	1.94E-19	3.37E-19	5.50E-19	8.50E-19
2.000E 00	6.199E 03	1.06E-20	1.99E-20	3.69E-20	6.20E-20	9.84E-20	1.48E-19
3.000E 00	4.133E 03	5.88E-21	1.06E-20	1.85E-20	2.99E-20	4.58E-20	6.69E-20
4.000E 00	3.100E 03	2.68E-21	4.84E-21	8.44E-21	1.37E-20	2.09E-20	3.05E-20
5.000E 00	2.480E 03	5.90E-21	9.79E-21	1.54E-20	2.31E-20	3.31E-20	4.54E-20
6.000E 00	2.066E 03	5.07E-21	8.45E-21	1.33E-20	2.00E-20	2.85E-20	3.91E-20
7.000E 00	1.771E 03	4.67E-21	7.82E-21	1.24E-20	1.85E-20	2.65E-20	3.64E-20
8.000E 00	1.550E 03	4.52E-21	7.60E-21	1.20E-20	1.81E-20	2.60E-20	3.58E-20
9.000E 00	1.378E 03	4.57E-21	7.71E-21	1.22E-20	1.85E-20	2.65E-20	3.65E-20
9.500E 00	1.305E 03	4.63E-21	7.83E-21	1.24E-20	1.88E-20	2.70E-20	3.72E-20
1.000E 01	1.240E 03	4.70E-21	7.95E-21	1.27E-20	1.91E-20	2.75E-20	3.79E-20
1.050E 01	1.181E 03	4.77E-21	8.08E-21	1.29E-20	1.95E-20	2.80E-20	3.86E-20
1.100E 01	1.127E 03	4.83E-21	8.19E-21	1.31E-20	1.98E-20	2.84E-20	3.92E-20
1.150E 01	1.078E 03	4.82E-21	8.16E-21	1.30E-20	1.95E-20	2.80E-20	3.85E-20
1.200E 01	1.033E 03	4.60E-21	7.76E-21	1.23E-20	1.85E-20	2.64E-20	3.61E-20
1.250E 01	9.918E 02	4.27E-21	7.17E-21	1.13E-20	1.69E-20	2.41E-20	3.29E-20
1.283E 01	9.663E 02	4.16E-21	6.98E-21	1.10E-20	1.65E-20	2.35E-20	3.22E-20
1.300E 01	9.537E 02	4.04E-21	6.78E-21	1.07E-20	1.60E-20	2.28E-20	3.11E-20
1.350E 01	9.184E 02	3.75E-21	6.26E-21	9.83E-21	1.47E-20	2.08E-20	2.84E-20
1.361E 01	9.110E 02	3.55E-18	3.48E-18	3.41E-18	3.32E-18	3.20E-18	3.07E-18
1.400E 01	8.856E 02	3.71E-18	3.64E-18	3.56E-18	3.47E-18	3.35E-18	3.21E-18
1.445E 01	8.580E 02	3.94E-18	3.88E-18	3.81E-18	3.71E-18	3.60E-18	3.45E-18
1.495E 01	8.293E 02	4.08E-18	4.02E-18	3.94E-18	3.84E-18	3.72E-18	3.57E-18
1.500E 01	8.265E 02	4.82E-18	4.81E-18	4.78E-18	4.72E-18	4.63E-18	4.49E-18
1.600E 01	7.749E 02	5.08E-18	5.07E-18	5.05E-18	4.99E-18	4.90E-18	4.76E-18
1.700E 01	7.293E 02	7.55E-18	7.53E-18	7.47E-18	7.37E-18	7.21E-18	6.98E-18
1.800E 01	6.888E 02	8.16E-18	8.13E-18	8.06E-18	7.95E-18	7.77E-18	7.53E-18
1.900E 01	6.525E 02	9.67E-18	9.61E-18	9.51E-18	9.37E-18	9.14E-18	8.84E-18
2.000E 01	6.199E 02	1.02E-17	1.01E-17	9.98E-18	9.83E-18	9.58E-18	9.27E-18

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ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 21000	T(DEG-K) 22000	T(DEG-K) 23000	T(DEG-K) 24000
2.500E-01	4.959E 04	6.69E-17	9.59E-17	1.32E-16	1.74E-16
5.000E-01	2.480E 04	8.39E-18	1.20E-17	1.63E-17	2.15E-17
7.500E-01	1.653E 04	2.54E-18	3.61E-18	4.90E-18	6.42E-18
1.000E 00	1.240E 04	1.25E-18	1.76E-18	2.36E-18	3.06E-18
2.000E 00	6.199E 03	2.13E-19	2.93E-19	3.87E-19	4.92E-19
3.000E 00	4.133E 03	9.35E-20	1.25E-19	1.62E-19	2.02E-19
4.000E 00	3.100E 03	4.26E-20	5.71E-20	7.36E-20	9.18E-20
5.000E 00	2.480E 03	6.54E-20	8.27E-20	1.01E-19	1.20E-19
6.000E 00	2.066E 03	5.59E-20	7.05E-20	8.63E-20	1.02E-19
7.000E 00	1.771E 03	5.17E-20	6.52E-20	7.98E-20	9.46E-20
8.000E 00	1.550E 03	5.03E-20	6.37E-20	7.80E-20	9.25E-20
9.000E 00	1.378E 03	5.11E-20	6.47E-20	7.94E-20	9.41E-20
9.500E 00	1.305E 03	5.20E-20	6.58E-20	8.07E-20	9.58E-20
1.000E 01	1.240E 03	5.29E-20	6.70E-20	8.22E-20	9.75E-20
1.050E 01	1.181E 03	5.38E-20	6.82E-20	8.37E-20	9.93E-20
1.100E 01	1.127E 03	5.46E-20	6.92E-20	8.49E-20	1.01E-19
1.150E 01	1.078E 03	5.34E-20	6.74E-20	8.25E-20	9.76E-20
1.200E 01	1.033E 03	5.01E-20	6.31E-20	7.69E-20	9.07E-20
1.250E 01	9.918E 02	4.57E-20	5.74E-20	6.99E-20	8.23E-20
1.283E 01	9.663E 02	4.48E-20	5.63E-20	6.86E-20	8.09E-20
1.300E 01	9.537E 02	4.34E-20	5.45E-20	6.64E-20	7.82E-20
1.350E 01	9.184E 02	3.98E-20	4.99E-20	6.06E-20	7.13E-20
1.361E 01	9.110E 02	2.92E-18	2.75E-18	2.56E-18	2.47E-18
1.400E 01	8.856E 02	3.05E-18	2.87E-18	2.67E-18	2.58E-18
1.445E 01	8.580E 02	3.29E-18	3.10E-18	2.89E-18	2.79E-18
1.495E 01	8.293E 02	3.40E-18	3.20E-18	2.99E-18	2.88E-18
1.500E 01	8.265E 02	4.32E-18	4.11E-18	3.86E-18	3.72E-18
1.600E 01	7.749E 02	4.58E-18	4.36E-18	4.09E-18	3.94E-18
1.700E 01	7.293E 02	6.71E-18	6.36E-18	5.96E-18	5.73E-18
1.800E 01	6.888E 02	7.22E-18	6.85E-18	6.41E-18	6.16E-18
1.900E 01	6.525E 02	8.47E-18	8.01E-18	7.50E-18	7.20E-18
2.000E 01	6.199E 02	8.87E-18	8.40E-18	7.85E-18	7.54E-18

Table 4-6

EFFECTIVE CROSS SECTION OF THE OXYGEN ION , OII(SQ. CM)

ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 3000	T(DEG-K) 4000	T(DEG-K) 5000	T(DEG-K) 6000	T(DEG-K) 7000	T(DEG-K) 8000
2.500E-01	4.959E 04	0.	0.	0.	0.	0.	0.
5.000E-01	2.480E 04	0.	0.	0.	0.	0.	0.
7.500E-01	1.653E 04	0.	0.	0.	0.	0.	0.
1.000E 00	1.240E 04	0.	0.	0.	0.	0.	0.
1.500E 00	8.265E 03	0.	0.	0.	0.	0.	0.
2.000E 00	6.199E 03	0.	0.	0.	0.	0.	0.
2.500E 00	4.959E 03	0.	0.	0.	0.	0.	0.
3.000E 00	4.133E 03	0.	0.	0.	0.	0.	0.
3.500E 00	3.542E 03	0.	0.	0.	0.	0.	0.
4.000E 00	3.100E 03	0.	0.	0.	0.	0.	0.
5.000E 00	2.480E 03	0.	0.	0.	0.	0.	0.
6.000E 00	2.066E 03	0.	0.	0.	0.	0.	0.
6.310E 00	1.965E 03	0.	0.	0.	0.	0.	0.
7.000E 00	1.771E 03	0.	0.	0.	0.	0.	0.
8.000E 00	1.550E 03	0.	0.	0.	0.	0.	0.
8.500E 00	1.459E 03	0.	0.	0.	0.	0.	0.
9.000E 00	1.378E 03	0.	0.	0.	0.	0.	0.
9.210E 00	1.346E 03	0.	0.	0.	0.	0.	1.28E-34
9.500E 00	1.305E 03	0.	0.	0.	0.	0.	1.31E-34
1.000E 01	1.240E 03	0.	0.	0.	0.	0.	1.35E-34
1.050E 01	1.181E 03	0.	0.	0.	0.	0.	1.40E-34
1.100E 01	1.127E 03	0.	0.	0.	0.	0.	1.47E-34
1.150E 01	1.078E 03	0.	0.	0.	0.	0.	1.53E-34
1.170E 01	1.060E 03	0.	0.	0.	0.	0.	1.55E-34
1.200E 01	1.033E 03	0.	0.	0.	0.	0.	2.46E-33
1.230E 01	1.008E 03	0.	0.	0.	0.	0.	1.42E-32
1.250E 01	9.918E 02	0.	0.	0.	0.	0.	1.41E-32
1.300E 01	9.537E 02	0.	0.	0.	0.	0.	1.38E-32
1.400E 01	8.856E 02	0.	0.	0.	0.	0.	1.33E-32
1.600E 01	7.749E 02	0.	0.	0.	0.	0.	1.27E-32
1.800E 01	6.888E 02	0.	0.	0.	0.	0.	1.25E-32
2.000E 01	6.199E 02	0.	0.	0.	0.	0.	1.24E-32

ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 9000	T(DEG-K) 10000	T(DEG-K) 11000	T(DEG-K) 12000	T(DEG-K) 13000	T(DEG-K) 14000
2.500E-01	4.959E 04	3.85E-33	4.00E-31	1.80E-29	4.29E-28	6.33E-27	6.36E-26
5.000E-01	2.480E 04	4.61E-34	4.76E-32	2.13E-30	5.06E-29	7.44E-28	7.46E-27
7.500E-01	1.653E 04	1.35E-34	1.39E-32	6.21E-31	1.47E-29	2.16E-28	2.16E-27
1.000E 00	1.240E 04	5.59E-34	4.61E-32	1.70E-30	3.45E-29	4.39E-28	3.87E-27
1.500E 00	8.265E 03	1.73E-34	1.57E-32	5.93E-31	1.23E-29	1.59E-28	1.22E-27
2.000E 00	6.199E 03	1.01E-34	1.60E-32	5.68E-31	1.12E-29	1.37E-28	1.09E-27
2.500E 00	4.959E 03	2.76E-34	2.85E-32	9.26E-31	1.68E-29	1.95E-28	1.54E-27
3.000E 00	4.133E 03	1.54E-34	1.69E-32	5.48E-31	9.96E-30	1.15E-28	9.08E-28
3.500E 00	3.542E 03	3.17E-34	2.39E-32	7.16E-31	1.22E-29	1.33E-28	1.02E-27
4.000E 00	3.100E 03	4.51E-34	3.18E-32	9.26E-31	1.54E-29	1.65E-28	1.25E-27
5.000E 00	2.480E 03	3.01E-34	2.01E-32	5.67E-31	9.21E-30	9.73E-29	7.27E-28
6.000E 00	2.066E 03	7.49E-34	3.76E-32	9.09E-31	1.30E-29	1.25E-28	8.61E-28
6.310E 00	1.965E 03	7.38E-33	3.04E-31	6.35E-30	7.96E-29	6.74E-28	4.20E-27
7.000E 00	1.771E 03	5.31E-33	2.21E-31	4.66E-30	5.89E-29	5.03E-28	3.17E-27
8.000E 00	1.550E 03	3.39E-33	1.42E-31	3.00E-30	3.80E-29	3.26E-28	2.05E-27
8.500E 00	1.459E 03	2.77E-33	1.16E-31	2.45E-30	3.12E-29	2.68E-28	1.69E-27
9.000E 00	1.378E 03	2.29E-33	9.60E-32	2.04E-30	2.59E-29	2.23E-28	1.41E-27
9.210E 00	1.346E 03	1.09E-32	3.38E-31	5.75E-30	6.17E-29	4.66E-28	2.66E-27
9.500E 00	1.305E 03	1.09E-32	3.35E-31	5.65E-30	6.03E-29	4.53E-28	2.57E-27
1.000E 01	1.240E 03	1.09E-32	3.31E-31	5.53E-30	5.85E-29	4.36E-28	2.45E-27
1.050E 01	1.181E 03	1.10E-32	3.33E-31	5.50E-30	5.76E-29	4.25E-28	2.37E-27
1.100E 01	1.127E 03	1.13E-32	3.38E-31	5.53E-30	5.74E-29	4.21E-28	2.33E-27
1.150E 01	1.078E 03	1.15E-32	3.43E-31	5.58E-30	5.75E-29	4.18E-28	2.30E-27
1.170E 01	1.060E 03	1.16E-32	3.47E-31	5.66E-30	5.84E-29	4.26E-28	2.35E-27
1.200E 01	1.033E 03	1.23E-31	2.86E-30	3.80E-29	3.32E-28	2.09E-27	1.02E-26
1.230E 01	1.008E 03	5.92E-31	1.18E-29	1.36E-28	1.05E-27	5.94E-27	2.63E-26
1.250E 01	9.918E 02	5.87E-31	1.17E-29	1.35E-28	1.04E-27	5.89E-27	2.61E-26
1.300E 01	9.537E 02	5.75E-31	1.14E-29	1.32E-28	1.02E-27	5.74E-27	2.54E-26
1.400E 01	8.856E 02	5.55E-31	1.10E-29	1.27E-28	9.74E-28	5.49E-27	2.42E-26
1.600E 01	7.749E 02	5.29E-31	1.04E-29	1.20E-28	9.20E-28	5.17E-27	2.27E-26
1.800E 01	6.888E 02	5.19E-31	1.03E-29	1.18E-28	9.01E-28	5.05E-27	2.22E-26
2.000E 01	6.199E 02	5.11E-31	1.01E-29	1.15E-28	8.80E-28	4.92E-27	2.15E-26

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Table 4-6 (cont.)

EFFECTIVE CROSS SECTION OF THE OXYGEN ION , OII(SQ. CM)

ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 15000	T(DEG-K) 16000	T(DEG-K) 17000	T(DEG-K) 18000	T(DEG-K) 19000	T(DEG-K) 20000
2.500E-01	4.959E 04	4.71E-25	2.72E-24	1.28E-23	5.07E-23	1.74E-22	5.30E-22
5.000E-01	2.480E 04	5.51E-26	3.17E-25	1.49E-24	5.89E-24	2.02E-23	6.14E-23
7.500E-01	1.653E 04	1.59E-26	9.11E-26	4.26E-25	1.68E-24	5.77E-24	1.75E-23
1.000E 00	1.240E 04	2.56E-26	1.34E-25	5.74E-25	2.09E-24	6.72E-24	1.91E-23
1.500E 00	8.265E 03	9.60E-27	5.08E-26	2.21E-25	8.15E-25	2.64E-24	7.56E-24
2.000E 00	6.199E 03	7.67E-27	3.92E-26	1.66E-25	5.94E-25	1.87E-24	5.23E-24
2.500E 00	4.959E 03	9.73E-27	4.76E-26	1.93E-25	6.67E-25	2.03E-24	5.51E-24
3.000E 00	4.133E 03	5.75E-27	2.81E-26	1.14E-25	3.93E-25	1.19E-24	3.24E-24
3.500E 00	3.542E 03	6.12E-27	2.89E-26	1.14E-25	3.84E-25	1.14E-24	3.03E-24
4.000E 00	3.100E 03	7.35E-27	3.43E-26	1.33E-25	4.44E-25	1.31E-24	3.45E-24
5.000E 00	2.480E 03	4.22E-27	1.95E-26	7.52E-26	2.50E-25	7.29E-25	1.92E-24
6.000E 00	2.066E 03	4.65E-27	2.02E-26	7.44E-26	2.36E-25	6.67E-25	1.70E-24
6.310E 00	1.965E 03	2.05E-26	8.17E-26	2.77E-25	8.22E-25	2.17E-24	5.18E-24
7.000E 00	1.771E 03	1.56E-26	6.25E-26	2.14E-25	6.38E-25	1.69E-24	4.07E-24
8.000E 00	1.550E 03	1.01E-26	4.08E-26	1.40E-25	4.17E-25	1.11E-24	2.67E-24
8.500E 00	1.459E 03	8.35E-27	3.36E-26	1.15E-25	3.45E-25	9.18E-25	2.22E-24
9.000E 00	1.378E 03	6.98E-27	2.82E-26	9.67E-26	2.90E-25	7.71E-25	1.86E-24
9.210E 00	1.346E 03	1.21E-26	4.57E-26	1.49E-25	4.25E-25	1.09E-24	2.55E-24
9.500E 00	1.305E 03	1.17E-26	4.39E-26	1.42E-25	4.06E-25	1.04E-24	2.43E-24
1.000E 01	1.240E 03	1.10E-26	4.13E-26	1.33E-25	3.78E-25	9.63E-25	2.24E-24
1.050E 01	1.181E 03	1.06E-26	3.95E-26	1.27E-25	3.58E-25	9.07E-25	2.11E-24
1.100E 01	1.127E 03	1.04E-26	3.83E-26	1.22E-25	3.43E-25	8.68E-25	2.01E-24
1.150E 01	1.078E 03	1.02E-26	3.74E-26	1.19E-25	3.33E-25	8.37E-25	1.93E-24
1.170E 01	1.060E 03	1.04E-26	3.85E-26	1.22E-25	3.44E-25	8.68E-25	2.01E-24
1.200E 01	1.033E 03	4.02E-26	1.34E-25	3.91E-25	1.01E-24	2.37E-24	5.13E-24
1.230E 01	1.008E 03	9.55E-26	2.95E-25	8.06E-25	1.97E-24	4.37E-24	9.03E-24
1.250E 01	9.918E 02	9.48E-26	2.94E-25	8.02E-25	1.96E-24	4.36E-24	9.00E-24
1.300E 01	9.537E 02	9.21E-26	2.85E-25	7.77E-25	1.89E-24	4.21E-24	8.69E-24
1.400E 01	8.856E 02	8.77E-26	2.70E-25	7.36E-25	1.79E-24	3.97E-24	8.18E-24
1.600E 01	7.749E 02	8.20E-26	2.52E-25	6.83E-25	1.66E-24	3.66E-24	7.50E-24
1.800E 01	6.888E 02	7.97E-26	2.44E-25	6.61E-25	1.60E-24	3.52E-24	7.20E-24
2.000E 01	6.199E 02	7.71E-26	2.36E-25	6.35E-25	1.53E-24	3.35E-24	6.83E-24

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ENERGY (EV)	WAVE LENGTH (ANGSTROM)	T(DEG-K) 21000	T(DEG-K) 22000	T(DEG-K) 23000	T(DEG-K) 24000
2.500E-01	4.959E 04	1.45E-21	3.63E-21	8.40E-21	1.81E-20
5.000E-01	2.480E 04	1.68E-22	4.19E-22	9.67E-22	2.09E-21
7.500E-01	1.653E 04	4.79E-23	1.20E-22	2.76E-22	5.96E-22
1.000E 00	1.240E 04	4.93E-23	1.17E-22	2.56E-22	5.29E-22
1.500E 00	8.265E 03	1.96E-23	4.67E-23	1.03E-22	2.14E-22
2.000E 00	6.199E 03	1.33E-23	3.10E-23	6.73E-23	1.37E-22
2.500E 00	4.959E 03	1.36E-23	3.09E-23	6.54E-23	1.30E-22
3.000E 00	4.133E 03	8.01E-24	1.82E-23	3.85E-23	7.65E-23
3.500E 00	3.542E 03	7.35E-24	1.64E-23	3.42E-23	6.71E-23
4.000E 00	3.100E 03	8.29E-24	1.84E-23	3.80E-23	7.42E-23
5.000E 00	2.480E 03	4.59E-24	1.01E-23	2.09E-23	4.07E-23
6.000E 00	2.066E 03	3.95E-24	8.53E-24	1.72E-23	3.28E-23
6.310E 00	1.965E 03	1.14E-23	2.34E-23	4.51E-23	8.23E-23
7.000E 00	1.771E 03	9.00E-24	1.85E-23	3.59E-23	6.56E-23
8.000E 00	1.550E 03	5.92E-24	1.22E-23	2.37E-23	4.34E-23
8.500E 00	1.459E 03	4.91E-24	1.01E-23	1.97E-23	3.61E-23
9.000E 00	1.378E 03	4.14E-24	8.55E-24	1.66E-23	3.05E-23
9.210E 00	1.346E 03	5.51E-24	1.11E-23	2.11E-23	3.81E-23
9.500E 00	1.305E 03	5.24E-24	1.05E-23	2.00E-23	3.61E-23
1.000E 01	1.240E 03	4.83E-24	9.70E-24	1.84E-23	3.30E-23
1.050E 01	1.181E 03	4.52E-24	9.05E-24	1.71E-23	3.07E-23
1.100E 01	1.127E 03	4.29E-24	8.57E-24	1.62E-23	2.89E-23
1.150E 01	1.078E 03	4.11E-24	8.20E-24	1.54E-23	2.75E-23
1.170E 01	1.060E 03	4.29E-24	8.56E-24	1.61E-23	2.89E-23
1.200E 01	1.033E 03	1.03E-23	1.95E-23	3.50E-23	5.99E-23
1.230E 01	1.008E 03	1.74E-23	3.18E-23	5.48E-23	9.10E-23
1.250E 01	9.918E 02	1.74E-23	3.17E-23	5.48E-23	9.09E-23
1.300E 01	9.537E 02	1.67E-23	3.05E-23	5.26E-23	8.73E-23
1.400E 01	8.856E 02	1.57E-23	2.86E-23	4.93E-23	8.16E-23
1.600E 01	7.749E 02	1.44E-23	2.60E-23	4.47E-23	7.37E-23
1.800E 01	6.888E 02	1.37E-23	2.48E-23	4.24E-23	6.98E-23
2.000E 01	6.199E 02	1.30E-23	2.34E-23	3.98E-23	6.53E-23

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Table 4-7

ATOMIC LINE TRANSITIONS FOR NEUTRAL CARBON, CI – ABSORPTION f-NUMBERS

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	Absorption f-Number $f_{nn'}$	NBS f-Number
1	2101 3112	2101 3212	0.628	19737	1.06^{-1}	
2	2101 3213	2101 4300	0.667	18583	9.85^{-1}	
3	2101 3112	2101 4000	0.693	17886	1.52^{-1}	
4	2101 3232	2101 4300	0.694	17860	1.03	
5	2101 3233	2101 4300	0.707	17532	1.04	
6	2101 3112	2101 3213	0.734	16886	6.92^{-1}	7.4^{-1}
7	2101 3212	2101 4300	0.773	16035	1.14	
8	2101 3130	2101 4000	0.825	15025	1.81^{-1}	
9	2101 3131	2101 4000	0.848	14617	1.86^{-1}	
10	2101 3011	2101 3111	0.852	14548	2.75^{-1}	
11	2101 3131	2101 3232	0.860	14412	7.24^{-1}	
12	2101 3213	2101 5300	0.976	12700	1.59^{-1}	
13	2101 3131	2101 3231	0.985	12584	2.76^{-1}	2.49^{-1}
14	2101 3232	2101 5300	1.003	12358	1.63^{-1}	
15	2101 3233	2101 5300	1.016	12200	1.66^{-1}	
16	2101 3132	2101 4000	1.053	11771	2.31^{-1}	
17	2101 3132	2101 3233	1.054	11760	9.5^{-1}	7.0^{-1}
18	2101 3130	2101 3231	1.062	11671	1.19	9.6^{-1}
19	2101 3132	2101 3232	1.065	11638	1.79^{-1}	1.32^{-1}
20	2101 3212	2101 5300	1.082		1.75^{-1}	
21	2101 3111	2101 3212	1.094	11330	9.21^{-1}	6.3^{-1}
22	2101 3111	2101 4000	1.159	10695	2.54^{-1}	
23	2101 3031	2101 3132	1.163	10658	6.32^{-1}	5.0^{-1}
24	2101 3132	2101 3231	1.190	10416	1.34^{-2}	
25	2101 3111	2101 3211	1.224	10127	3.42^{-1}	2.62^{-1}
26	2101 3031	2101 3130	1.291	9601	1.4^{-1}	1.0^{-1}

Table 4-7 (cont.)

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	Absorption f-Number $f_{nn'}$	NBS f-Number
27	2101 3011	2101 3112	1.318	9404	7.16^{-1}	4.2^{-1}
28	2101 3031	2101 3131	1.368	9061	4.46^{-1}	3.1^{-1}
29	2101 3011	2101 3110	1.487	8336	1.62^{-1}	1.1^{-1}
30	2101 3112	2101 5000	1.497	8280	1.90^{-2}	
31	2101 3131	2101 5000	1.652	7503	2.10^{-2}	
32	2101 3130	2101 5000	1.729	7169	2.20^{-2}	
33	2101 3132	2101 5000	1.857	6675	2.36^{-2}	
34	2101 3111	2101 4200	1.867	6607	1.03^{-2}	
35	2101 3111	2101 5000	1.963	6314	2.50^{-2}	
36	2101 2110	2101 3011	5.002	2578	6.76^{-2}	9.4^{-2}
37	2101 2112	2101 3011	6.424	1929	7.29^{-2}	8.2^{-2}
38	2101 2110	2101 4000	7.013	1767	1.41^{-2}	
39	2101 2110	2101 3211	7.078	1751	7.48^{-2}	1.2^{-1}
40	2101 2102	2101 3031	7.481	1657	1.05^{-1}	1.7^{-1}
41	2101 2110	2101 5000	7.717	1606	5.34^{-3}	
42	2101 2110	2101 4200	7.721	1605	3.67^{-2}	
43	2101 2131	2102 2132	7.947	1560	2.83^{-1}	9.1^{-2}
44	2101 2110	2101 5200	8.030	1544	1.97^{-3}	
45	2101 2110	2101 6000	8.031	1543	2.60^{-3}	
46	2101 2110	2101 6200	8.191	1513	1.16^{-2}	
47	2101 2110	2101 7000	8.203	1511	1.47^{-3}	
48	2101 2110	2101 7200	8.302	1493	7.40^{-3}	
49	2101 2110	2101 8000	8.302	1493	9.07^{-4}	
50	2101 2112	2101 3212	8.368	1481	1.10^{-2}	1.1^{-2}
51	2101 2110	2101 8200	8.377	1480	5.01^{-3}	
52	2101 2112	2101 4000	8.433	1470	1.42^{-2}	
53	2101 2112	2101 3213	8.474	1463	6.25^{-2}	9.3^{-2}
54	2101 2112	2101 3211	8.498	1459	7.46^{-4}	7.0^{-3}
55	2102 2150	2102 3051	8.658	1431	1.90^{-1}	1.3^{-1}

Table 4-7 (cont.)

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	Absorption f-Number $f_{nn'}$	NBS f-Number
56	2101 2112	2101 5000	9.137	1357	5.26^{-3}	
57	2101 2112	2101 4200	9.141	1356	3.62^{-2}	
58	2101 2131	2102 2131	9.332	1328	2.03^{-1}	3.8^{-2}
59	2101 2112	2101 5200	9.450	1312	1.93^{-2}	
60	2101 2112	2101 6000	9.451	1312	2.55^{-3}	
61	2101 2112	2101 6200	9.611	1290	1.14^{-2}	
62	2101 2112	2101 7000	9.623	1288	1.43^{-3}	
63	2101 2131	2101 4000	9.697	1278	1.95^{-2}	
64	2101 2131	2101 3233	9.698	1278		3.8^{-3}
65	2101 2131	2101 3232	9.709	1277	7.67^{-2}	6.3^{-2}
66	2101 2112	2101 7200	9.722	1275	7.22^{-3}	
67	2101 2112	2101 8000	9.722	1275	8.85^{-4}	
68	2101 2112	2101 8200	9.797	1265	4.88^{-3}	
69	2101 2131	2101 3231	9.834	1260	2.60^{-2}	2.9^{-2}
70	2101 2131	2101 5000	10.401	1191.7	7.19^{-3}	
71	2101 2131	2101 4200	10.405	1191.3	4.95^{-2}	
72	2101 2131	2101 5200	10.714	1156.9	2.63^{-2}	
73	2101 2131	2101 6000	10.715	1156.8	3.47^{-3}	
74	2101 2112	2102 2112	10.873	1140.0	7.05^{-1}	
75	2101 2131	2101 6200	10.875	1139.8	1.55^{-2}	
76	2101 2131	2101 7000	10.887	1139.5	1.95^{-3}	
77	2101 2131	2101 7200	10.986	1128.3	9.80^{-3}	
78	2101 2131	2101 8000	10.986	1128.3	1.20^{-3}	
79	2101 2131	2101 8200	11.061	1120.6	6.59^{-3}	
80	2101 2110	2102 2111	12.181	1017.6	1.05	
81	2101 2131	2102 2130	13.119	944.81	3.79^{-1}	2.7^{-1}
82	2101 2112	2102 2111	13.601	911.33	2.95^{-1}	

Table 4-8

ATOMIC LINE TRANSITIONS FOR SINGLY IONIZED CARBON, CII – ABSORPTION f-NUMBERS

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	Absorption f-Number $f_{nn'}$	NBS f-Number
1	2201 2121	2202 2122	9.288	1335	2.72^{-1}	2.7^{-1}
2	2201 2121	2202 2120	11.960	1036.4	6.17^{-2}	5.9^{-2}
3	2201 2121	2202 2121	13.715	903.76	7.23^{-1}	5.2^{-1}
4	2201 2121	2201 3020	14.445	858.08	5.62^{-2}	4.6^{-2}
5	2202 2141	2202 3041	15.336	808.23	1.23^{-1}	
6	2201 2121	2201 3222	18.041	688.08	2.79^{-1}	2.6^{-1}
7	2202 2141	2202 3242	19.033	651.24	4.88^{-1}	
8	2202 2141	2202 3241	19.317	641.66	1.65^{-1}	
9	2201 2121	2201 4000	19.489	636.00	1.05^{-2}	

Table 4-9

ATOMIC LINE TRANSITIONS FOR NEUTRAL NITROGEN, NI – ABSORPTION f-NUMBERS

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	Absorption f-Number $f_{nn'}$	NBS f-Number
1	1101 3222	1101 4300	0.65720	18860	9.14^{-1}	
2	1101 3242	1101 4300	0.67370	18398	9.37^{-1}	
3	1101 3241	1101 4300	0.68870	17998	9.58^{-1}	
4	1101 3223	1101 4300	0.68960	17974	9.59^{-1}	
5	1101 3243	1101 4300	0.7101	17455	9.88^{-1}	
6	1101 3221	1101 4300	0.7228	17149	1.00	
7	1101 3121	1101 4000	0.7525	16471	1.35^{-1}	
8	1101 3121	1101 3221	0.8455	14659	1.63^{-1}	
9	1101 3122	1101 4000	0.8715	14222	1.56^{-1}	
10	1101 3140	1101 4000	0.8817	14058	1.58^{-1}	
11	1101 3121	1101 3222	0.9111	13604	5.26^{-1}	
12	1101 3021	1101 3120	0.9158	13534	7.63^{-2}	
13	1101 3222	1101 5300	0.9220	13443	1.50^{-1}	
14	1101 3242	1101 5300	0.9389	13201	1.53^{-1}	
15	1101 3241	1101 5300	0.9539	12994	1.55^{-1}	
16	1101 3223	1101 5300	0.9548	12981	1.56^{-1}	
17	1101 3243	1101 5300	0.9753	12706	1.59^{-1}	
18	1101 3221	1101 5300	0.9880	12545	1.61^{-1}	
19	1101 3122	1101 3223	0.9977	12423	6.45^{-1}	7.1^{-1}
20	1101 3140	1101 3241	1.0088	12286	7.77^{-1}	8.5^{-1}
21	1101 3122	1101 3222	1.0301	12033	1.19^{-1}	1.30^{-1}
22	1101 3141	1101 4000	1.0355	11970	1.86^{-1}	1.71^{-1}
23	1101 3142	1101 4000	1.1189	11078	2.01^{-1}	1.68^{-1}
24	1101 3141	1101 3241	1.1626	10661	2.24^{-1}	2.16^{-1}
25	1101 3141	1101 3242	1.1776	10526	6.80^{-1}	6.88^{-1}

Table 4-9 (cont.)

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	Absorption f-Number $f_{nn'}$	NBS f-Number
26	1101 3142	1101 3243	1.2246	10122	7.92^{-1}	8.02^{-1}
27	1101 3142	1101 3242	1.2610	9830	1.46^{-1}	1.44^{-1}
28	1101 3120	1101 4000	1.2747	9724	2.29^{-1}	
29	1101 3021	1101 3122	1.3190	9397	5.50^{-1}	4.78^{-1}
30	1101 3120	1101 3221	1.3677	9063	1.05	9.45^{-1}
31	1101 3041	1101 3142	1.4258	8693	5.94^{-1}	3.58^{-1}
32	1101 3021	1101 3121	1.4380	8620	3.60^{-1}	3.18^{-1}
33	1101 3041	1101 3141	1.5092	8213	3.79^{-1}	2.31^{-1}
34	1101 3121	1101 4200	1.5527	7983	2.71^{-2}	
35	1101 3041	1101 3140	1.6630	7453	1.39^{-1}	8.8^{-2}
36	1101 3122	1101 4200	1.6717	7415	2.91^{-2}	
37	1101 3140	1101 4200	1.6819	7370	2.93^{-2}	
38	1101 3141	1101 4200	1.8357	6752	3.20^{-2}	
39	1101 3142	1101 4200	1.9191	6459	3.34^{-2}	
40	1101 3120	1101 4200	2.0749	5974	3.62^{-2}	
41	1101 3021	1101 4100	2.5708	4821	1.39^{-2}	
42	1101 3041	1101 4100	2.9250	4238	1.58^{-2}	
43	1101 3021	1101 5100	3.1072	3989	1.76^{-2}	
44	1101 3041	1101 5100	3.4614	3581	1.96^{-2}	
45	1101 3021	1101 6100	3.4724	3570	1.20^{-2}	
46	1101 3041	1101 6100	3.8266	3239	1.33^{-2}	
47	1101 2121	1101 3021		1743	6.34^{-2}	9.1^{-2}
48	1101 2122	1101 3021	8.3024	1493	7.40^{-2}	1.1^{-1}
49	1101 2121	1102 3029	8.7810	1412	4.35^{-2}	2.6^{-2}
50	1101 2121	1101 4000	9.3013	1333	1.66^{-2}	5.3^{-3}
51	1101 2121	1101 3221	9.3943	1319	1.19^{-2}	3.4^{-2}
52	1101 2121	1101 3222	9.4599	1310	3.60^{-2}	5.6^{-2}

Table 4-9 (cont.)

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	Absorption f-Number $f_{nn'}$	NBS f-Number
53	1101 2122	1102 3029	9.9726	1243	8.90^{-2}	1.1^{-1}
54	1101 2121	1101 5000	10.0560	1233	4.18^{-3}	
55	1101 2121	1101 4200	10.1015	1227	3.32^{-2}	
56	1101 2140	1101 3041	10.3320	1200	1.84^{-1}	3.5^{-1}
57	1101 2121	1101 6000	10.3948	1192	1.55^{-3}	
58	1101 2121	1101 5200	10.4175	1190	2.09^{-2}	
59	1101 2122	1101 4000	10.4929	1181	1.87^{-2}	1.4^{-2}
60	1101 2121	1101 7000	10.5708	1173	7.38^{-4}	
61	1101 2121	1101 6200	10.5846	1171	1.24^{-2}	
62	1101 2122	1101 3221	10.5859	1171	5.36^{-4}	8.2^{-4}
63	1101 2122	1101 3223	10.6191	1167	4.52^{-2}	3.4^{-2}
64	1101 2122	1101 3222	10.6515	1164	8.10^{-3}	9.5^{-3}
65	1101 2121	1101 8000	10.6749	1161	4.16^{-4}	
66	1101 2121	1101 7200	10.6824	1160	7.77^{-3}	
67	1101 2121	1101 8200	10.7567	1152	5.18^{-3}	
68	1101 2140	1104 2141	10.9267	1134	4.54^{-1}	1.3^{-1}
69	1101 2121	1102 4000	11.1999	1107	2.00^{-2}	
70	1101 2122	1101 5000	11.2476	1102	4.68^{-3}	3.6^{-3}
71	1101 2122	1101 4200	11.2931	1098	3.71^{-2}	
72	1101 2121	1102 3221	11.3018	1097	1.43^{-2}	
73	1101 2121	1102 3222	11.3193	1095	1.12^{-2}	
74	1101 2121	1104 2122	11.5500	1073	1.33^{-1}	
75	1101 2122	1101 6000	11.5860	1070	1.73^{-3}	
76	1101 2122	1101 5200	11.6090	1068	2.33^{-2}	
77	1101 2122	1101 7000	11.7620	1054	8.21^{-4}	
78	1101 2122	1101 6200	11.7760	1053	1.38^{-2}	
79	1101 2122	1101 8000	11.8660	1044	4.62^{-4}	
80	1101 2122	1101 7200	11.8740	1044	8.64^{-3}	

Table 4-9 (cont.)

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	Absorption f-Number $f_{nn'}$	NBS f-Number
81	1101 2122	1101 8200	11.9480	1037	5.75^{-3}	
82	1101 2121	1102 4200	12.0000	1033	2.19^{-2}	
83	1101 2121	1102 6000	12.2958	1008	1.83^{-3}	
84	1101 2121	1102 5200	12.3164	1006	1.38^{-2}	
85	1101 2122	1102 4000	12.3915	1000	2.21^{-2}	
86	1101 2122	1102 3223	12.4365	992.1	3.53^{-2}	
87	1101 2122	1102 3221	12.4934	992.1	5.70^{-3}	
88	1101 2122	1102 3222	12.5109	990.7	2.22^{-2}	
89	1101 2140	1101 4000	12.8768	962.6	2.30^{-2}	
90	1101 2140	1101 3241	13.0037	953.2	1.32^{-1}	
91	1101 2122	1102 5000	13.1466	942.8	5.47^{-3}	
92	1101 2122	1102 4200	13.1900	939.7	4.34^{-2}	
93	1101 2122	1102 6000	13.4850	919.2	2.01^{-3}	
94	1101 2122	1102 5200	13.5080	917.6	2.72^{-2}	
95	1101 2140	1101 5000	13.6310	909.3	5.67^{-3}	
96	1101 2140	1101 4200	13.6770	906.3	9.00^{-2}	
97	1101 2140	1101 6000	13.9703	887.2	2.08^{-3}	
98	1101 2140	1101 5200	13.9930	885.8	5.63^{-2}	
99	1101 2140	1101 7000	14.1463	876.2	9.88^{-4}	
100	1101 2140	1101 6200	14.1601	874.3	3.32^{-2}	
101	1101 2140	1101 8000	14.2504	869.8	5.55^{-4}	
102	1101 2140	1101 7200	14.2570	869.4	2.08^{-2}	
103	1101 2140	1101 8200	14.3320	852.9	1.38^{-2}	

Table 4-10

ATOMIC LINE TRANSITIONS FOR SINGLY IONIZED NITROGEN, NII – ABSORPTION f-NUMBERS

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	Absorption f-Number $f_{nn'}$	NBS f-Number
1	1201 2131	1202 2132	11.4240	1085	2.26^{-1}	1.7^{-1}
2	1201 2131	1202 2131	13.5435	915.2	1.16^{-1}	2.2^{-1}
3	1201 2110	1201 3011	14.4590	857.3	1.01^{-1}	
4	1201 2112	1202 2112	15.9931	769.4	5.71^{-1}	4.5^{-1}
5	1201 2112	1201 3011	16.6134	746.1	1.16^{-1}	1.0^{-1}
6	1201 2110	1202 2111	16.6381	745.0	7.92^{-1}	4.0^{-1}
7	1201 2131	1201 3031	18.4690	671.1	1.28^{-1}	8.9^{-2}
8	1201 2112	1202 2111	18.792	659.4	2.22^{-1}	3.0^{-1}
9	1201 2131	1202 2130	19.2355	644.4	3.06^{-1}	2.3^{-1}
10	1201 2110	1201 3211	19.534	634.5	4.16^{-1}	3.2^{-1}

Table 4-11

ATOMIC LINE TRANSITIONS FOR NEUTRAL OXYGEN, OI – ABSORPTION f-NUMBERS

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	Absorption f-Number $f_{nn'}$	NBS f-Number
1	0101 3232	0101 4100	0.226	54845	1.90^{-1}	
2	0101 3252	0101 4100	0.235	52745	1.97^{-1}	
3	0101 3232	0101 4300	0.681	18201	9.72^{-1}	
4	0101 3252	0101 4300	0.689	17990	9.84^{-1}	
5	0101 3232	0101 5100	0.770	16097	2.15^{-3}	
6	0101 3252	0101 5100	0.779	15911	2.17^{-3}	
7	0101 3131	0101 4000	0.884	14021	1.57^{-1}	1.63^{-1}
8	0101 3232	0101 5300	0.987	12558	1.61^{-1}	
9	0101 3252	0101 5300	0.995	12457	1.62^{-1}	
10	0101 3131	0101 3232	1.098	11289	7.49^{-1}	7.5^{-1}
11	0101 3151	0101 4000	1.132	10950	2.01^{-1}	1.73^{-1}
12	0101 3151	0101 3252	1.338	9263	9.13^{-1}	9.0^{-1}
13	0101 3030	0101 3131	1.467	8449	9.50^{-1}	8.98^{-1}
14	0101 3050	0101 3151	1.594	7776	1.03	9.22^{-1}
15	0101 3131	0101 5000	1.683	7365	1.15^{-2}	1.62^{-2}
16	0101 3131	0101 4200	1.767	7015	5.24^{-2}	3.98^{-2}
17	0101 3151	0101 5000	1.931	6419	1.32^{-2}	1.48^{-2}
18	0101 3151	0101 4200	2.015	6151	5.98^{-2}	6.64^{-2}
19	0101 3131	0101 5200	2.079	5962	3.97^{-3}	
20	0101 3151	0101 5200	2.327	5327	4.44^{-3}	1.40^{-2}
21	0101 3030	0101 4100	2.792	4439	7.28^{-3}	5.6^{-3}
22	0101 3050	0101 4100	3.167	3914	8.26^{-3}	2.29^{-3}
23	0101 3030	0101 5100	3.336	3716	1.28^{-2}	
24	0101 3050	0101 5100	3.711	3340	1.43^{-2}	

Table 4-11 (cont.)

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	Absorption f-Number $f_{nn'}$	NBS f-Number
25	0101 2131	0101 3030	9.501	1305	4.71^{-2}	3.1^{-2}
26	0101 2110	0103 3011	10.182	1217	1.51^{-1}	1.3^{-1}
27	0101 2112	0102 3012	10.761	1152	1.20^{-1}	9.0^{-2}
28	0101 2110	0102 4000	11.007	1126	1.85^{-2}	
29	0101 2110	0102 5000	11.806	1050	4.89^{-3}	
30	0101 2131	0101 4000	11.852	1046	1.99^{-2}	
31	0101 2131	0101 3232	12.067	1027	2.18^{-2}	1.0^{-2}
32	0101 2110	0102 6000	12.160	1019	1.88^{-3}	
33	0101 2112	0103 3011	12.404	997.7	4.61^{-2}	3.5^{-2}
34	0101 2131	0102 3032	12.521	989.9	7.75^{-2}	4.7^{-2}
35	0101 2131	0101 5000	12.651	979.8	5.24^{-3}	
36	0101 2110	0103 4000	12.699	976.1	2.13^{-2}	
37	0101 2131	0101 4200	12.735	973.3	1.54^{-2}	
38	0101 2110	0103 3219	12.911	960.0	7.01^{-2}	
39	0101 2131	0101 6000	13.005	953.1	2.01^{-3}	
40	0101 2131	0101 5200	13.047	950.0	1.05^{-2}	
41	0101 2112	0102 3212	13.220	937.6	1.88^{-2}	
42	0101 2112	0102 4000	13.229	937.0	2.22^{-2}	
43	0101 2131	0101 6200	13.232	936.7	6.57^{-3}	
44	0101 2131	0101 7200	13.331	929.8	4.27^{-3}	
45	0101 2131	0101 8200	13.394	925.4	2.93^{-3}	
46	0101 2112	0102 3213	13.447	921.8	3.07^{-2}	1.5^{-2}
47	0101 2110	0103 5000	13.498	918.3	5.60^{-3}	
48	0101 2112	0102 3211	13.555	914.4	4.97^{-3}	
49	0101 2110	0103 4200	13.582	912.6	4.94^{-2}	
50	0101 2110	0103 6000	13.852	894.8	2.14^{-3}	

Table 4-11 (cont.)

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	Absorption f-Number $f_{nn'}$	NBS f-Number
51	0101 2110	0103 5200	13.894	892.1	3.35^{-2}	
52	0101 2112	0102 5000	14.029	883.5	5.82^{-3}	
53	0101 2131	0103 3031	14.104	878.8	5.24^{-2}	3.7^{-2}
54	0101 2112	0102 4200	14.113	878.3	3.85^{-2}	
55	0101 2112	0102 6000	14.382	861.8	2.23^{-3}	
56	0101 2112	0102 5200	14.425	859.3	2.61^{-2}	
57	0101 2112	0103 4000	14.921	830.7	2.50^{-2}	
58	0101 2131	0102 4000	15.177	816.7	2.54^{-2}	
59	0101 2131	0102 3230	15.273	811.6	6.91^{-3}	
60	0101 2131	0102 3231	15.273	811.6	1.55^{-2}	7.7^{-3}
61	0101 2131	0102 3232	15.401	804.8	1.22^{-2}	
62	0101 2112	0103 5000	15.721	788.4	6.52^{-3}	
63	0101 2112	0103 4200	15.805	784.2	1.44^{-2}	
64	0101 2131	0102 5000	15.976	775.9	6.62^{-3}	
65	0101 2131	0102 4200	16.060	771.8	2.43^{-2}	
66	0101 2112	0103 6000	16.074	771.1	2.49^{-3}	
67	0101 2112	0103 5200	16.117	769.1	9.71^{-3}	
68	0101 2131	0102 6000	16.330	759.0	2.53^{-3}	
69	0101 2131	0102 5200	16.372	757.1	1.64^{-2}	
70	0101 2131	0103 4000	16.869	734.8	2.83^{-2}	
71	0101 2131	0103 3239	17.080	725.7	2.32^{-2}	
72	0101 2131	0103 5000	17.668	701.6	7.32^{-3}	
73	0101 2131	0103 4200	17.752	698.2	1.61^{-2}	
74	0101 2131	0103 6000	18.022	687.8	2.79^{-3}	
75	0101 2131	0103 5200	18.064	686.2	1.09^{-2}	

Table 4-12

ATOMIC LINE TRANSITIONS FOR SINGLY IONIZED OXYGEN, OII – ABSORPTION f-NUMBERS

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	Absorption f-Number $f_{nn'}$	NBS f-Number
1	0201 2140	0204 2141	14.877	833.2	4.00^{-1}	4.3^{-1}
2	0201 2121	0204 2122	15.561	796.5	1.16^{-1}	7.0^{-2}
3	0201 2122	0204 2122	17.255	718.4	2.32^{-1}	2.5^{-1}
4	0201 2121	0201 3021	18.423	672.8	6.66^{-2}	6.3^{-2}
5	0201 2121	0204 2120	19.246	644.0	1.15^{-1}	1.5^{-1}

Table 4-13

ATOMIC LINE TRANSITIONS FOR NEUTRAL CARBON, CI – ELECTRON IMPACT HALF-WIDTHS AND LINE SHIFTS

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (A)	T = 2500°K		T = 5000°K		T = 10,000°K		T = 15,000°K		T = 20,000°K		T = 25,000°K	
					$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)
1	2101 3112	2101 3212	0.628	19737	1.18^{-21}	1.86^{-21}	1.56^{-21}	2.13^{-21}	2.14^{-21}	2.32^{-21}	2.56^{-21}	2.36^{-21}	2.86^{-21}	2.34^{-21}	3.09^{-21}	2.31^{-21}
2	2101 3231	2101 4300	0.667	18583	3.46^{-18}	7.64^{-21}	5.55^{-18}	6.43^{-21}	6.39^{-18}	4.66^{-21}	5.85^{-18}	4.36^{-21}	5.19^{-18}	6.05^{-21}	4.62^{-18}	5.56^{-21}
3	2101 3112	2101 4000	0.693	17886	3.13^{-21}	5.34^{-21}	3.91^{-21}	6.26^{-21}	5.00^{-21}	6.88^{-21}	5.72^{-21}	6.97^{-21}	6.23^{-21}	6.89^{-21}	6.61^{-21}	6.74^{-21}
4	2101 3232	2101 4300	0.694	17860	3.46^{-18}	7.64^{-21}	5.53^{-18}	6.43^{-21}	6.39^{-18}	4.66^{-21}	5.85^{-18}	4.36^{-21}	5.19^{-18}	6.05^{-21}	4.62^{-18}	5.56^{-21}
5	2101 3233	2101 4300	0.707	17532	3.46^{-18}	7.64^{-21}	5.53^{-18}	6.43^{-21}	6.39^{-18}	4.66^{-21}	5.85^{-18}	4.36^{-21}	5.19^{-18}	6.05^{-21}	4.62^{-18}	5.56^{-21}
6	2101 3112	2101 3213	0.734	16886	1.49^{-21}	2.38^{-21}	1.89^{-21}	2.71^{-21}	2.48^{-21}	2.87^{-21}	2.89^{-21}	2.85^{-21}	3.18^{-21}	2.78^{-21}	3.41^{-21}	2.69^{-21}
7	2101 3212	2101 4300	0.773	16035	3.46^{-18}	7.64^{-21}	5.53^{-18}	6.43^{-21}	6.39^{-18}	4.66^{-21}	5.85^{-18}	4.36^{-21}	5.19^{-18}	6.05^{-21}	4.62^{-18}	5.56^{-21}
8	2101 3130	2101 4000	0.825	15025	3.13^{-21}	5.34^{-21}	3.91^{-21}	6.26^{-21}	5.00^{-21}	6.88^{-21}	5.72^{-21}	6.97^{-21}	6.23^{-21}	6.89^{-21}	6.61^{-21}	6.74^{-21}
9	2101 3131	2101 4000	0.848	14617	3.13^{-21}	5.34^{-21}	3.91^{-21}	6.26^{-21}	5.00^{-21}	6.88^{-21}	5.72^{-21}	6.97^{-21}	6.23^{-21}	6.89^{-21}	6.61^{-21}	6.74^{-21}
10	2101 3011	2101 3111	0.852	14548	6.03^{-22}	9.69^{-22}	7.83^{-22}	1.13^{-21}	1.08^{-21}	1.29^{-21}	1.30^{-21}	1.35^{-21}	1.47^{-21}	1.38^{-21}	1.59^{-21}	1.39^{-21}
11	2101 3131	2101 3232	0.860	14412	1.44^{-21}	2.34^{-21}	1.81^{-21}	2.68^{-21}	2.35^{-21}	2.87^{-21}	2.73^{-21}	2.86^{-21}	3.01^{-21}	2.80^{-21}	3.23^{-21}	2.72^{-21}
12	2101 3213	2101 5300	0.976	12700	1.15^{-19}	-6.05^{-20}	1.37^{-19}	-2.40^{-20}	2.05^{-19}	1.05^{-20}	2.66^{-19}	6.49^{-21}	2.95^{-19}	2.13^{-20}	3.22^{-19}	1.87^{-20}
13	2101 3131	2101 3231	0.985	12584	1.87^{-21}	3.04^{-21}	2.32^{-21}	3.41^{-21}	2.93^{-21}	3.51^{-21}	3.31^{-21}	3.42^{-21}	3.58^{-21}	3.28^{-21}	3.78^{-21}	3.14^{-21}
14	2101 3232	2101 5300	1.003	12358	1.15^{-19}	-6.05^{-20}	1.37^{-19}	-2.40^{-20}	2.05^{-19}	1.05^{-20}	2.66^{-19}	6.49^{-21}	2.95^{-19}	2.13^{-20}	3.22^{-19}	1.87^{-20}
15	2101 3233	2101 5300	1.016	12200	1.15^{-19}	-6.05^{-20}	1.37^{-19}	-2.40^{-20}	2.05^{-19}	1.05^{-20}	2.66^{-19}	6.49^{-21}	2.95^{-19}	2.13^{-20}	3.22^{-19}	1.87^{-20}
16	2101 3132	2101 4000	1.053	11771	3.13^{-21}	5.34^{-21}	3.91^{-21}	6.26^{-21}	5.00^{-21}	6.88^{-21}	5.72^{-21}	6.97^{-21}	6.23^{-21}	6.89^{-21}	6.61^{-21}	6.74^{-21}
17	2101 3132	2101 3233	1.054	11760	1.46^{-21}	2.39^{-21}	1.84^{-21}	2.74^{-21}	2.35^{-21}	2.95^{-21}	2.70^{-21}	2.95^{-21}	2.96^{-21}	2.89^{-21}	3.16^{-21}	2.81^{-21}
18	2101 3130	2101 3231	1.062	11671	1.87^{-21}	3.04^{-21}	2.32^{-21}	3.41^{-21}	2.93^{-21}	3.51^{-21}	3.31^{-21}	3.42^{-21}	3.58^{-21}	3.28^{-21}	3.78^{-21}	3.14^{-21}
19	2101 3132	2101 3232	1.065	11638	1.44^{-21}	2.34^{-21}	1.81^{-21}	2.68^{-21}	2.35^{-21}	2.87^{-21}	2.73^{-21}	2.86^{-21}	3.01^{-21}	2.80^{-21}	3.23^{-21}	2.72^{-21}
20	2101 3212	2101 5300	1.082		1.15^{-19}	-6.05^{-20}	1.37^{-19}	-2.40^{-20}	2.05^{-19}	1.05^{-20}	2.66^{-19}	6.49^{-21}	2.95^{-19}	2.13^{-20}	3.22^{-19}	1.87^{-20}
21	2101 3111	2101 3212	1.094	11330	1.81^{-21}	1.86^{-21}	1.56^{-21}	2.13^{-21}	2.14^{-21}	2.32^{-21}	2.56^{-21}	2.36^{-21}	2.86^{-21}	2.34^{-21}	3.09^{-21}	2.31^{-21}
22	2101 3111	2101 4000	1.159	10695	3.13^{-21}	5.34^{-21}	3.91^{-21}	6.26^{-21}	5.00^{-21}	6.88^{-21}	5.72^{-21}	6.97^{-21}	6.23^{-21}	6.89^{-21}	6.61^{-21}	6.74^{-21}
23	2101 3031	2101 3132	1.163	10658	6.53^{-22}	1.13^{-21}	8.20^{-22}	1.32^{-21}	1.08^{-21}	1.50^{-21}	1.28^{-21}	1.56^{-21}	1.44^{-21}	1.57^{-21}	1.56^{-21}	1.56^{-21}
24	2101 3132	2101 3231	1.190	10416	1.87^{-21}	3.04^{-21}	2.32^{-21}	3.41^{-21}	2.93^{-21}	3.51^{-21}	3.31^{-21}	3.42^{-21}	3.58^{-21}	3.28^{-21}	3.78^{-21}	3.14^{-21}
25	2101 3111	2101 3211	1.224	10127	1.58^{-21}	2.49^{-21}	2.02^{-21}	2.79^{-21}	2.62^{-21}	2.93^{-21}	3.02^{-21}	2.91^{-21}	3.31^{-21}	2.83^{-21}	3.53^{-21}	2.74^{-21}
26	2101 3031	2101 3130	1.291	9601	7.68^{-22}	1.32^{-21}	9.22^{-22}	1.58^{-21}	1.15^{-21}	1.83^{-21}	1.31^{-21}	1.93^{-21}	1.43^{-21}	1.96^{-21}	1.53^{-21}	1.97^{-21}
27	2101 3011	2101 3112	1.318	9404	1.05^{-21}	1.78^{-21}	1.32^{-21}	2.06^{-21}	1.68^{-21}	2.22^{-21}	1.92^{-21}	2.22^{-21}	2.09^{-21}	2.16^{-21}	2.22^{-21}	2.09^{-21}
28	2101 3011	2101 3131	1.368	9061	8.08^{-22}	1.39^{-21}	1.01^{-21}	1.63^{-21}	1.31^{-21}	1.81^{-21}	1.52^{-21}	1.85^{-21}	1.68^{-21}	1.84^{-21}	1.80^{-21}	1.80^{-21}
29	2101 3011	2101 3110	1.487	8336	1.38^{-21}	2.28^{-21}	1.74^{-21}	5.60^{-21}	2.18^{-21}	2.71^{-21}	2.43^{-21}	2.63^{-21}	2.60^{-21}	2.52^{-21}	2.71^{-21}	2.41^{-21}
30	2101 3112	2101 5000	1.497	8280	1.38^{-20}	2.25^{-20}	1.74^{-20}	2.53^{-20}	2.20^{-20}	2.58^{-20}	2.46^{-20}	2.47^{-20}	2.63^{-20}	2.35^{-20}	2.75^{-20}	2.23^{-20}
31	2101 3131	2101 5000	1.652	7503	1.38^{-20}	2.25^{-20}	1.74^{-20}	2.53^{-20}	2.20^{-20}	2.58^{-20}	2.46^{-20}	2.47^{-20}	2.63^{-20}	2.35^{-20}	2.75^{-20}	2.23^{-20}
32	2101 3130	2101 5000	1.729	7169	1.38^{-20}	2.25^{-20}	1.74^{-20}	2.53^{-20}	2.20^{-20}	2.58^{-20}	2.46^{-20}	2.47^{-20}	2.63^{-20}	2.35^{-20}	2.75^{-20}	2.23^{-20}
33	2101 3132	2101 5000	1.857	6675	1.38^{-20}	2.25^{-20}	1.74^{-20}	2.53^{-20}	2.20^{-20}	2.58^{-20}	2.46^{-20}	2.47^{-20}	2.63^{-20}	2.35^{-20}	2.75^{-20}	2.23^{-20}
34	2101 3111	2101 4200	1.867	6607	5.58^{-20}	2.74^{-20}	7.74^{-20}	1.18^{-20}	1.09^{-19}	-5.36^{-21}	1.49^{-19}	-1.33^{-20}	1.59^{-19}	-1.06^{-20}	1.73^{-19}	-9.08^{-21}
35	2101 3111	2101 5000	1.963	6314	1.38^{-20}	2.25^{-20}	1.74^{-20}	2.53^{-20}	2.20^{-20}	2.58^{-20}	2.46^{-20}	2.47^{-20}	2.63^{-20}	2.35^{-20}	2.75^{-20}	2.23^{-20}
36	2101 2110	2101 3011	5.002	2578	7.30^{-22}	1.25^{-21}	9.01^{-22}	1.47^{-21}	1.13^{-21}	1.65^{-21}	1.28^{-21}	1.69^{-21}	1.38^{-21}	1.69^{-21}	1.45^{-21}	1.66^{-21}
37	2101 2112	2101 3011	6.424	1929	7.30^{-22}	1.25^{-21}	9.01^{-22}	1.47^{-21}	1.13^{-21}	1.65^{-21}	1.28^{-21}	1.69^{-21}	1.38^{-21}	1.69^{-21}	1.45^{-21}	1.66^{-21}
38	2101 2110	2101 4000	7.013	1767	3.13^{-21}	5.34^{-21}	3.91^{-21}	6.26^{-21}	5.00^{-21}	6.88^{-21}	5.72^{-21}	6.97^{-21}	6.23^{-21}	6.89^{-21}	6.61^{-21}	6.74^{-21}
39	2101 2110	2101 3211	7.078	1751	1.58^{-21}	2.49^{-21}	2.02^{-21}	2.79^{-21}	2.62^{-21}	2.93^{-21}	3.02^{-21}	2.91^{-21}	3.31^{-21}	2.83^{-21}	3.53^{-21}	2.74^{-21}
40	2101 3131	2101 3031	7.481	1657	5.73^{-22}	1.00^{-21}	6.98^{-22}	1.18^{-21}	8.73^{-22}	1.36^{-21}	9.95^{-22}	1.43^{-21}	1.09^{-21}	1.45^{-21}	1.15^{-21}	1.45^{-21}

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Table 4-13 (cont.)

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	T = 2500°K		T = 5000°K		T = 10,000°K		T = 15,000°K		T = 20,000°K		T = 25,000°K	
					$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)
41	2101 2110	2101 5000	7.717	1606	1.38^{-20}	2.25^{-20}	1.70^{-20}	2.53^{-20}	2.20^{-20}	2.58^{-20}	2.46^{-20}	2.47^{-20}	2.63^{-20}	2.35^{-20}	2.75^{-20}	2.23^{-20}
42	2101 2110	2101 4200	7.721	1605	5.58^{-20}	2.74^{-20}	7.74^{-20}	1.18^{-20}	1.09^{-19}	-5.36^{-21}	1.49^{-19}	-1.33^{-20}	1.59^{-19}	-1.06^{-20}	1.73^{-19}	-9.08^{-21}
43	2101 2131	2102 2132	7.947	1560	3.17^{-23}	2.31^{-24}	8.99^{-23}	-5.31^{-24}	2.08^{-22}	9.95^{-25}	2.77^{-22}	-7.38^{-24}	3.15^{-22}	-4.65^{-24}	3.40^{-22}	-3.44^{-24}
44	2101 2110	2101 5200	8.030	1544	1.90^{-19}	5.29^{-20}	3.51^{-19}	-8.82^{-21}	6.90^{-19}	-1.38^{-20}	9.06^{-19}	-3.82^{-20}	1.02^{-18}	-3.12^{-20}	1.11^{-18}	-2.70^{-20}
45	2101 2110	2101 6000	8.031	1543	3.35^{-20}	5.38^{-20}	4.29^{-20}	5.93^{-20}	5.44^{-20}	5.90^{-20}	6.11^{-20}	5.57^{-20}	6.54^{-20}	5.23^{-20}	6.84^{-20}	4.94^{-20}
46	2101 2110	2101 6200	8.141	1513	4.72^{-19}	1.34^{-19}	7.37^{-19}	-1.10^{-20}	1.30^{-18}	-3.46^{-20}	1.72^{-18}	-8.62^{-20}	1.93^{-18}	-7.31^{-20}	2.10^{-18}	-6.40^{-20}
47	2101 2110	2101 7000	8.203	1511	6.90^{-20}	1.05^{-19}	9.13^{-20}	1.13^{-19}	1.19^{-19}	1.09^{-19}	1.34^{-19}	1.02^{-19}	1.44^{-19}	9.55^{-20}	1.51^{-19}	9.00^{-20}
48	2101 2110	2101 7200	8.302	1493	2.56^{-18}	2.32^{-20}	3.79^{-18}	-2.35^{-19}	5.38^{-18}	-1.63^{-19}	5.54^{-18}	-1.72^{-19}	5.47^{-18}	-1.47^{-19}	5.24^{-18}	-1.30^{-19}
49	2101 2110	2101 8000	8.302	1493	1.45^{-19}	2.03^{-19}	1.95^{-19}	2.10^{-19}	2.53^{-19}	1.96^{-19}	2.83^{-19}	1.80^{-19}	3.02^{-19}	1.67^{-19}	3.13^{-19}	1.55^{-19}
50	2101 2112	2101 3212	8.368	1481	1.18^{-21}	1.86^{-21}	1.56^{-21}	2.13^{-21}	2.14^{-21}	2.32^{-21}	2.56^{-21}	2.36^{-21}	2.86^{-21}	2.34^{-21}	3.09^{-21}	2.31^{-21}
51	2101 2110	2101 8200	8.377	1480	1.60^{-18}	4.66^{-19}	3.31^{-18}	-2.35^{-21}	6.77^{-18}	-1.19^{-19}	8.88^{-18}	-2.65^{-19}	9.98^{-18}	-2.33^{-19}	1.08^{-17}	-2.10^{-19}
52	2101 2112	2101 4000	8.433	1470	3.13^{-21}	5.34^{-21}	3.91^{-21}	6.26^{-21}	5.00^{-21}	6.88^{-21}	5.72^{-21}	6.97^{-21}	6.23^{-21}	6.89^{-21}	6.61^{-21}	6.74^{-21}
53	2101 2112	2101 3213	8.474	1463	1.49^{-21}	2.38^{-21}	1.89^{-21}	2.71^{-21}	2.48^{-21}	2.87^{-21}	2.89^{-21}	2.85^{-21}	3.18^{-21}	2.78^{-21}	3.41^{-21}	2.69^{-21}
54	2101 2112	2101 3211	8.498	1459	1.58^{-21}	2.49^{-21}	2.02^{-21}	2.79^{-21}	2.62^{-21}	2.93^{-21}	3.02^{-21}	2.91^{-21}	3.31^{-21}	2.83^{-21}	3.53^{-21}	2.74^{-21}
55	2102 2150	2102 3051	8.658	1431												
56	2101 2112	2101 5000	0.137	1357	1.38^{-20}	2.25^{-20}	1.70^{-20}	2.53^{-20}	2.20^{-20}	2.58^{-20}	2.46^{-20}	2.47^{-20}	2.63^{-20}	2.35^{-20}	2.75^{-20}	2.23^{-20}
57	2101 2112	2101 4200	9.141	1356	5.58^{-20}	2.74^{-20}	7.74^{-20}	1.18^{-20}	1.09^{-19}	-5.36^{-21}	1.49^{-19}	-1.33^{-20}	1.59^{-19}	-1.06^{-20}	1.73^{-19}	-9.08^{-21}
58	2101 2131	2102 2131	9.332	1328	2.45^{-23}	1.91^{-23}	3.09^{-23}	1.39^{-23}	5.57^{-23}	5.03^{-24}	9.50^{-23}	-3.52^{-24}	1.37^{-22}	-6.67^{-24}	1.67^{-22}	-4.72^{-24}
59	2101 2112	2101 5200	9.450	1312	1.90^{-19}	5.29^{-20}	3.51^{-19}	-8.82^{-21}	6.90^{-19}	-1.38^{-20}	9.06^{-19}	-3.82^{-20}	1.02^{-18}	-3.12^{-20}	1.11^{-18}	-2.70^{-20}
60	2101 2112	2101 6000	9.451	1312	3.35^{-20}	5.38^{-20}	4.29^{-20}	5.93^{-20}	5.44^{-20}	5.90^{-20}	6.11^{-20}	5.57^{-20}	6.54^{-20}	5.23^{-20}	6.84^{-20}	4.94^{-20}
61	2101 2112	2101 6200	9.611	1290	4.72^{-19}	1.34^{-19}	7.37^{-19}	-1.10^{-20}	1.30^{-18}	-3.46^{-20}	1.72^{-18}	-8.62^{-20}	1.93^{-18}	-7.31^{-20}	2.10^{-18}	-6.40^{-20}
62	2101 2112	2101 7000	9.623	1288	6.90^{-20}	1.05^{-19}	9.13^{-20}	1.13^{-19}	1.19^{-19}	1.09^{-19}	1.34^{-19}	1.02^{-19}	1.44^{-19}	9.55^{-20}	1.51^{-19}	9.00^{-20}
63	2101 2131	2101 4000	9.697	1278	3.13^{-21}	5.34^{-21}	3.91^{-21}	6.26^{-21}	5.00^{-21}	6.88^{-21}	5.72^{-21}	6.97^{-21}	6.23^{-21}	6.89^{-21}	6.61^{-21}	6.74^{-21}
64	2101 2131	2101 3233	9.698	1278	1.46^{-21}	2.39^{-21}	1.84^{-21}	2.74^{-21}	2.35^{-21}	2.95^{-21}	2.70^{-21}	2.95^{-21}	2.96^{-21}	2.89^{-21}	3.16^{-21}	2.81^{-21}
65	2101 3131	2101 3232	9.709	1277	1.44^{-21}	2.34^{-21}	1.81^{-21}	2.68^{-21}	2.35^{-21}	2.87^{-21}	2.73^{-21}	2.86^{-21}	3.01^{-21}	2.80^{-21}	3.23^{-21}	2.72^{-21}
66	2101 2112	2101 7200	9.722	1275	2.56^{-18}	2.32^{-20}	3.79^{-21}	-2.35^{-19}	5.38^{-18}	-1.63^{-19}	5.54^{-18}	-1.72^{-19}	5.47^{-18}	-1.47^{-19}	5.24^{-18}	-1.30^{-19}
67	2101 2112	2101 8000	9.722	1275	1.45^{-19}	2.03^{-19}	1.95^{-19}	2.10^{-19}	2.53^{-19}	1.96^{-19}	2.83^{-19}	1.80^{-19}	3.02^{-19}	1.67^{-19}	3.13^{-19}	1.55^{-19}
68	2101 2112	2101 8200	9.797	1265	1.60^{-18}	4.66^{-19}	3.31^{-18}	-2.35^{-21}	6.77^{-18}	-1.19^{-19}	8.88^{-18}	-2.65^{-19}	9.98^{-18}	-2.33^{-19}	1.08^{-17}	-2.10^{-19}
69	2101 2131	2101 3231	9.834	1260	1.87^{-21}	3.04^{-21}	2.32^{-21}	3.41^{-21}	2.93^{-21}	3.31^{-21}	3.31^{-21}	3.42^{-21}	3.58^{-21}	3.28^{-21}	3.78^{-21}	3.14^{-21}
70	2101 2131	2101 5000	10.401	1191.7	1.38^{-20}	2.25^{-20}	1.70^{-20}	2.53^{-20}	2.20^{-20}	2.58^{-20}	2.46^{-20}	2.47^{-20}	2.63^{-20}	2.35^{-20}	2.75^{-20}	2.23^{-20}
71	2101 2131	2101 4200	10.405	1191.3	5.58^{-20}	2.74^{-20}	7.74^{-20}	1.18^{-20}	1.09^{-19}	-5.36^{-21}	1.49^{-19}	-1.33^{-20}	1.59^{-19}	-1.06^{-20}	1.73^{-19}	-9.08^{-21}
72	2101 2131	2101 5200	10.714	1156.9	1.90^{-19}	5.29^{-20}	3.51^{-19}	-8.82^{-21}	6.90^{-19}	-1.38^{-20}	9.06^{-19}	-3.82^{-20}	1.02^{-18}	-3.12^{-20}	1.11^{-18}	-2.70^{-20}
73	2101 2131	2101 6000	10.715	1156.8	3.35^{-20}	5.38^{-20}	4.29^{-20}	5.93^{-20}	5.44^{-20}	5.90^{-20}	6.11^{-20}	5.57^{-20}	6.54^{-20}	5.23^{-20}	6.84^{-20}	4.94^{-20}
74	2101 2112	2102 2112	10.873	1140.0	9.26^{-21}	2.04^{-24}	8.82^{-20}	2.62^{-24}	6.30^{-21}	7.07^{-24}	4.53^{-21}	1.11^{-23}	3.40^{-21}	8.08^{-24}	2.66^{-21}	1.19^{-23}
75	2101 2131	2101 6200	10.875	1139.8	4.72^{-19}	1.34^{-19}	7.37^{-19}	-1.10^{-20}	1.30^{-18}	-3.46^{-20}	1.72^{-18}	-8.62^{-20}	1.93^{-18}	-7.31^{-20}	2.10^{-18}	-6.40^{-20}
76	2101 2131	2101 7000	10.887	1139.5	6.90^{-20}	1.05^{-19}	9.13^{-20}	1.13^{-19}	1.19^{-19}	1.09^{-19}	1.34^{-19}	1.02^{-19}	1.44^{-19}	9.55^{-20}	1.51^{-19}	9.00^{-20}
77	2101 2131	2101 7200	10.896	1128.3	2.56^{-18}	2.32^{-20}	3.79^{-18}	-2.35^{-19}	5.38^{-18}	-1.63^{-19}	5.54^{-18}	-1.72^{-19}	5.47^{-18}	-1.47^{-19}	5.24^{-18}	-1.30^{-19}
78	2101 2131	2101 8000	10.986	1128.3	1.45^{-19}	2.03^{-19}	1.95^{-19}	2.10^{-19}	2.53^{-19}	1.96^{-19}	2.83^{-19}	1.80^{-19}	3.02^{-19}	1.67^{-19}	3.13^{-19}	1.55^{-19}
79	2101 2131	2101 8200	11.061	1120.6	1.60^{-18}	4.66^{-19}	3.31^{-18}	-2.35^{-21}	6.77^{-18}	-1.19^{-19}	8.88^{-18}	-2.65^{-19}	9.98^{-18}	-2.33^{-19}	1.08^{-17}	-2.10^{-19}
80	2101 2110	2102 2111	12.181	1017.6	8.93^{-23}	1.30^{-23}	1.34^{-22}	1.43^{-23}	1.59^{-22}	1.18^{-23}	1.63^{-22}	1.81^{-23}	1.64^{-22}	1.84^{-23}	1.63^{-22}	1.98^{-23}
81	2101 2131	2102 2130	13.119	944.81	1.07^{-21}	-1.24^{-24}	1.21^{-21}	2.25^{-24}	1.01^{-21}	3.36^{-24}	8.00^{-22}	3.92^{-24}	6.50^{-22}	3.47^{-24}	5.32^{-22}	3.23^{-24}
82	2101 2112	2102 2111	13.601	911.33	8.93^{-23}	1.30^{-23}	1.34^{-22}	1.43^{-23}	1.59^{-22}	1.18^{-23}	1.63^{-22}	1.81^{-23}	1.64^{-22}	1.84^{-23}	1.63^{-22}	1.98^{-23}

Table 4-14

ATOMIC LINE TRANSITIONS FOR SINGLY IONIZED CARBON, CII – ELECTRON IMPACT HALF-WIDTHS AND LINE SHIFTS

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	T = 2500°K		T = 5000°K		T = 10,000°K	
					$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)
1	2201 2121	2202 2122	9.288	1335	9.08^{-24}	1.21^{-23}	1.47^{-23}	1.25^{-23}	2.50^{-23}	1.26^{-23}
2	2201 2121	2202 2120	11.960	1036.4	1.53^{-23}	2.62^{-23}	1.90^{-23}	3.07^{-23}	2.55^{-23}	3.50^{-23}
3	2201 2121	2202 2121	13.715	903.76	2.84^{-23}	4.86^{-23}	3.54^{-23}	5.76^{-23}	4.56^{-23}	6.53^{-23}
4	2201 2121	2201 3020	14.445	858.08	2.49^{-22}	4.48^{-22}	3.00^{-22}	5.35^{-22}	3.81^{-22}	6.14^{-22}
5	2202 2141	2202 3041	15.336	808.23	2.53^{-22}	4.54^{-22}	3.04^{-22}	5.43^{-22}	3.84^{-22}	6.24^{-22}
6	2201 2121	2201 3222	18.041	688.08	1.63^{-22}	-2.93^{-22}	2.03^{-22}	-3.47^{-22}	2.71^{-22}	-3.69^{-22}
7	2202 2141	2202 3242	19.033	651.24	1.54^{-22}	-3.39^{-22}	2.02^{-22}	-3.86^{-22}	2.77^{-22}	-4.01^{-22}
8	2202 2141	2202 3241	19.317	641.66	1.54^{-22}	-3.39^{-22}	2.02^{-22}	-3.86^{-22}	2.77^{-22}	-4.01^{-22}
9	2201 2121	2201 4000	19.489	636.00	1.32^{-21}	2.26^{-21}	1.63^{-21}	2.67^{-21}	2.04^{-21}	2.99^{-21}

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	T = 15,000°K		T = 20,000°K		T = 25,000°K	
					$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)
1	2201 2121	2202 2122	9.288	1335	3.26^{-23}	1.30^{-23}	3.93^{-23}	1.36^{-23}	4.43^{-23}	1.41^{-23}
2	2201 2121	2202 2120	11.960	1036.4	3.15^{-23}	3.66^{-23}	3.69^{-23}	3.70^{-23}	4.17^{-23}	3.71^{-23}
3	2201 2121	2202 2121	13.715	903.76	5.34^{-23}	6.69^{-23}	5.98^{-23}	6.62^{-23}	6.51^{-23}	6.49^{-23}
4	2201 2121	2201 3020	14.445	858.08	4.37^{-22}	6.49^{-22}	4.80^{-22}	6.61^{-22}	5.10^{-22}	6.66^{-22}
5	2202 2141	2202 3041	15.336	808.23	4.41^{-22}	6.60^{-22}	4.86^{-22}	6.73^{-22}	5.16^{-22}	6.79^{-22}
6	2201 2121	2201 3222	18.041	688.08	3.15^{-22}	-3.66^{-22}	3.44^{-22}	-3.62^{-22}	3.68^{-22}	-3.49^{-22}
7	2202 2141	2202 3242	19.033	651.24	3.26^{-22}	-3.90^{-22}	3.59^{-22}	-3.78^{-22}	3.84^{-22}	-3.63^{-22}
8	2202 2141	2202 3241	19.317	641.66	3.26^{-22}	-3.90^{-22}	3.59^{-22}	-3.78^{-22}	3.84^{-22}	-3.63^{-22}
9	2201 2121	2201 4000	19.489	636.00	2.34^{-21}	3.08^{-21}	2.50^{-21}	3.08^{-21}	2.64^{-21}	3.03^{-21}

LOCKHEED PALO ALTO RESEARCH LABORATORY
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Table 4-15

ATOMIC LINE TRANSITIONS FOR NEUTRAL NITROGEN, NI – ELECTRON IMPACT HALF-WIDTHS AND LINE SHIFTS

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	T = 2500°K		T = 5000°K		T = 10,000°K		T = 15,000°K		T = 20,000°K		T = 25,000°K	
					$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)
1	1101 3222	1101 4300	0.65720	18860	1.80^{-20}	-1.77^{-20}	1.90^{-20}	-1.52^{-20}	1.87^{-20}	-1.22^{-20}	1.80^{-20}	-1.06^{-20}	1.73^{-20}	-9.59^{-21}	1.66^{-20}	-8.85^{-21}
2	1101 3240	1101 4300	0.67370	18398	1.80^{-20}	-1.77^{-20}	1.90^{-20}	-1.52^{-20}	1.87^{-20}	-1.22^{-20}	1.80^{-20}	-1.06^{-20}	1.73^{-20}	-9.59^{-21}	1.66^{-20}	-8.85^{-21}
3	1101 3241	1101 4300	0.68870	17998	1.80^{-20}	-1.77^{-20}	1.90^{-20}	-1.52^{-20}	1.87^{-20}	-1.22^{-20}	1.80^{-20}	-1.06^{-20}	1.73^{-20}	-9.59^{-21}	1.66^{-20}	-8.85^{-21}
4	1101 3223	1101 4300	0.68960	17974	1.80^{-20}	-1.77^{-20}	1.90^{-20}	-1.52^{-20}	1.87^{-20}	-1.22^{-20}	1.80^{-20}	-1.06^{-20}	1.73^{-20}	-9.59^{-21}	1.66^{-20}	-8.85^{-21}
5	1101 3243	1101 4300	0.7101	17455	1.80^{-20}	-1.77^{-20}	1.90^{-20}	-1.52^{-20}	1.87^{-20}	-1.22^{-20}	1.80^{-20}	-1.06^{-20}	1.73^{-20}	-9.59^{-21}	1.66^{-20}	-8.85^{-21}
6	1101 3221	1101 4300	0.7228	17149	1.80^{-20}	-1.77^{-20}	1.90^{-20}	-1.52^{-20}	1.87^{-20}	-1.22^{-20}	1.80^{-20}	-1.06^{-20}	1.73^{-20}	-9.59^{-21}	1.66^{-20}	-8.85^{-21}
7	1101 3121	1101 4000	0.7525	16471	2.80^{-21}	4.73^{-21}	3.51^{-21}	5.47^{-21}	4.46^{-21}	5.89^{-21}	5.06^{-21}	5.88^{-21}	5.48^{-21}	5.73^{-21}	5.77^{-21}	5.56^{-21}
8	1101 3121	1101 3221	0.8455	14659	1.92^{-21}	3.05^{-21}	2.36^{-21}	3.45^{-21}	2.92^{-21}	3.64^{-21}	3.28^{-21}	3.62^{-21}	3.54^{-21}	3.54^{-21}	3.74^{-21}	3.44^{-21}
9	1101 3122	1101 4000	0.8715	14222	2.80^{-21}	4.73^{-21}	3.51^{-21}	5.47^{-21}	4.46^{-21}	5.89^{-21}	5.06^{-21}	5.88^{-21}	5.48^{-21}	5.73^{-21}	5.77^{-21}	5.56^{-21}
10	1101 3140	1101 4000	0.8817	14058	2.80^{-21}	4.73^{-21}	3.51^{-21}	5.47^{-21}	4.46^{-21}	5.89^{-21}	5.06^{-21}	5.88^{-21}	5.48^{-21}	5.73^{-21}	5.77^{-21}	5.56^{-21}
11	1101 3121	1101 3222	0.9111	13604	2.30^{-21}	3.52^{-21}	2.79^{-21}	3.90^{-21}	3.36^{-21}	4.01^{-21}	3.71^{-21}	3.93^{-21}	3.96^{-21}	3.79^{-21}	4.14^{-21}	3.66^{-21}
12	1101 3021	1101 3120	0.9158	13534	2.98^{-22}	6.16^{-22}	5.27^{-22}	7.33^{-22}	7.39^{-22}	8.59^{-22}	8.98^{-22}	9.13^{-22}	1.02^{-21}	9.38^{-22}	1.12^{-21}	9.46^{-22}
13	1101 3222	1101 5300	0.9220	13443	2.84^{-20}	-3.91^{-20}	3.44^{-20}	-3.78^{-20}	3.87^{-20}	-3.34^{-20}	4.02^{-20}	-2.99^{-20}	4.06^{-20}	-2.73^{-20}	4.06^{-20}	-2.54^{-20}
14	1101 3242	1101 5300	0.9389	13201	2.84^{-20}	-3.91^{-20}	3.44^{-20}	-3.78^{-20}	3.87^{-20}	-3.34^{-20}	4.02^{-20}	-2.99^{-20}	4.06^{-20}	-2.73^{-20}	4.06^{-20}	-2.54^{-20}
15	1101 3241	1101 5300	0.9539	12994	2.84^{-20}	-3.91^{-20}	3.44^{-20}	-3.78^{-20}	3.87^{-20}	-3.34^{-20}	4.02^{-20}	-2.99^{-20}	4.06^{-20}	-2.73^{-20}	4.06^{-20}	-2.54^{-20}
16	1101 3223	1101 5300	0.9548	12981	2.84^{-20}	-3.91^{-20}	3.44^{-20}	-3.78^{-20}	3.87^{-20}	-3.34^{-20}	4.02^{-20}	-2.99^{-20}	4.06^{-20}	-2.73^{-20}	4.06^{-20}	-2.54^{-20}
17	1101 3243	1101 5300	0.9753	12706	2.84^{-20}	-3.91^{-20}	3.44^{-20}	-3.78^{-20}	3.87^{-20}	-3.34^{-20}	4.02^{-20}	-2.99^{-20}	4.06^{-20}	-2.73^{-20}	4.06^{-20}	-2.54^{-20}
18	1101 3221	1101 5300	0.9880	12545	2.84^{-20}	-3.91^{-20}	3.44^{-20}	-3.78^{-20}	3.87^{-20}	-3.34^{-20}	4.02^{-20}	-2.99^{-20}	4.06^{-20}	-2.73^{-20}	4.06^{-20}	-2.54^{-20}
19	1101 3122	1101 3223	0.9977	12423	2.10^{-21}	3.29^{-21}	2.56^{-21}	3.69^{-21}	3.12^{-21}	3.85^{-21}	3.46^{-21}	3.81^{-21}	3.71^{-21}	3.70^{-21}	3.89^{-21}	3.58^{-21}
20	1101 3140	1101 3241	1.0088	12286	1.47^{-21}	1.52^{-21}	2.11^{-21}	1.23^{-21}	2.94^{-21}	6.25^{-22}	3.53^{-21}	1.31^{-22}	3.99^{-21}	-2.19^{-22}	4.36^{-21}	-4.86^{-22}
21	1101 3122	1101 3222	1.0301	12033	2.30^{-21}	3.52^{-21}	2.79^{-21}	3.90^{-21}	3.36^{-21}	4.01^{-21}	3.71^{-21}	3.93^{-21}	3.96^{-21}	3.79^{-21}	4.14^{-21}	3.66^{-21}
22	1101 3141	1101 4000	1.0355	11970	2.80^{-21}	4.73^{-21}	3.51^{-21}	5.47^{-21}	4.46^{-21}	5.89^{-21}	5.06^{-21}	5.88^{-21}	5.48^{-21}	5.73^{-21}	5.77^{-21}	5.56^{-21}
23	1101 3142	1101 4000	1.1189	11078	2.80^{-21}	4.73^{-21}	3.51^{-21}	5.47^{-21}	4.46^{-21}	5.89^{-21}	5.06^{-21}	5.88^{-21}	5.48^{-21}	5.73^{-21}	5.77^{-21}	5.56^{-21}
24	1101 3141	1101 3241	1.1626	10661	1.47^{-21}	1.52^{-21}	2.11^{-21}	1.23^{-21}	2.94^{-21}	6.25^{-22}	3.53^{-21}	1.31^{-22}	3.99^{-21}	-2.19^{-22}	4.36^{-21}	-4.86^{-22}
25	1101 3141	1101 3242	1.1776	10526	1.24^{-21}	2.12^{-21}	1.50^{-21}	2.48^{-21}	1.87^{-21}	2.82^{-21}	2.10^{-21}	2.95^{-21}	2.27^{-21}	3.01^{-21}	2.39^{-21}	3.01^{-21}
26	1101 3142	1101 3243	1.2246	10122	2.09^{-21}	3.35^{-21}	2.53^{-21}	3.83^{-21}	3.04^{-21}	4.13^{-21}	3.33^{-21}	4.17^{-21}	3.54^{-21}	4.12^{-21}	2.89^{-21}	4.04^{-21}
27	1101 3142	1101 3242	1.2610	9830	1.24^{-21}	2.12^{-21}	1.50^{-21}	2.48^{-21}	1.87^{-21}	2.82^{-21}	2.10^{-21}	2.95^{-21}	2.27^{-21}	3.01^{-21}	2.39^{-21}	3.01^{-21}
28	1101 3120	1101 4000	1.2747	9724	2.80^{-21}	4.73^{-21}	3.51^{-21}	5.47^{-21}	4.46^{-21}	5.89^{-21}	5.06^{-21}	5.88^{-21}	5.48^{-21}	5.73^{-21}	5.77^{-21}	5.56^{-21}
29	1101 3021	1101 3122	1.3190	9397	5.99^{-22}	1.01^{-21}	7.55^{-22}	1.19^{-21}	9.84^{-22}	1.31^{-21}	1.15^{-21}	1.33^{-21}	1.27^{-21}	1.31^{-21}	1.36^{-21}	1.28^{-21}
30	1101 3120	1101 3221	1.3677	9063	1.92^{-21}	3.05^{-21}	2.36^{-21}	3.45^{-21}	2.92^{-21}	3.64^{-21}	3.28^{-21}	3.62^{-21}	3.54^{-21}	3.54^{-21}	3.74^{-21}	3.44^{-21}
31	1101 3041	1101 3142	1.4258	8693	4.82^{-22}	8.27^{-22}	6.05^{-22}	9.67^{-22}	7.98^{-22}	1.09^{-21}	9.45^{-22}	1.12^{-21}	1.06^{-21}	1.13^{-21}	1.15^{-21}	1.12^{-21}
32	1101 3021	1101 3121	1.4380	8620	6.88^{-22}	1.16^{-21}	8.64^{-22}	1.35^{-21}	1.11^{-21}	1.47^{-21}	1.28^{-21}	1.48^{-21}	1.41^{-21}	1.44^{-21}	1.50^{-21}	1.40^{-21}
33	1101 3041	1101 3141	1.5092	8213	5.13^{-22}	8.79^{-22}	6.41^{-22}	1.03^{-21}	8.39^{-22}	1.15^{-21}	9.88^{-22}	1.19^{-21}	1.10^{-21}	1.19^{-21}	1.19^{-21}	1.17^{-21}
34	1101 3121	1101 4200	1.5527	7983	2.45^{-20}	2.95^{-20}	2.74^{-20}	2.81^{-20}	2.93^{-20}	2.49^{-20}	2.98^{-20}	2.24^{-20}	2.99^{-20}	2.06^{-20}	2.96^{-20}	1.92^{-20}
35	1101 3041	1101 3140	1.6630	7453	5.94^{-22}	1.01^{-21}	7.41^{-22}	1.19^{-21}	9.58^{-22}	1.32^{-21}	1.11^{-21}	1.34^{-21}	1.23^{-21}	1.33^{-21}	1.32^{-21}	1.30^{-21}
36	1101 3122	1101 4200	1.6717	7415	2.45^{-20}	2.95^{-20}	2.74^{-20}	2.81^{-20}	2.93^{-20}	2.49^{-20}	2.98^{-20}	2.24^{-20}	2.99^{-20}	2.06^{-20}	2.96^{-20}	1.92^{-20}
37	1101 3140	1101 4200	1.6819	7370	2.45^{-20}	2.95^{-20}	2.74^{-20}	2.81^{-20}	2.93^{-20}	2.49^{-20}	2.98^{-20}	2.24^{-20}	2.99^{-20}	2.06^{-20}	2.96^{-20}	1.92^{-20}
38	1101 3141	1101 4200	1.8357	6752	2.45^{-20}	2.95^{-20}	2.74^{-20}	2.81^{-20}	2.93^{-20}	2.49^{-20}	2.98^{-20}	2.24^{-20}	2.99^{-20}	2.06^{-20}	2.96^{-20}	1.92^{-20}
39	1101 3142	1101 4200	1.9191	6459	2.45^{-20}	2.95^{-20}	2.74^{-20}	2.81^{-20}	2.93^{-20}	2.49^{-20}	2.98^{-20}	2.24^{-20}	2.99^{-20}	2.06^{-20}	2.96^{-20}	1.92^{-20}
40	1101 3120	1101 4200	2.0749	5974	2.45^{-20}	2.95^{-20}	2.74^{-20}	2.81^{-20}	2.93^{-20}	2.49^{-20}	2.98^{-20}	2.24^{-20}	2.99^{-20}	2.06^{-20}	2.96^{-20}	1.92^{-20}
41	1101 3021	1101 4100	2.5708	4821	2.38^{-21}	-7.48^{-22}	3.75^{-21}	-2.34^{-22}	5.51^{-21}	2.75^{-22}	6.59^{-21}	5.28^{-22}	7.32^{-21}	6.80^{-22}	7.84^{-21}	7.68^{-22}
42	1101 3041	1101 4100	2.925	4238	2.38^{-21}	-7.48^{-22}	3.75^{-21}	-2.34^{-22}	5.51^{-21}	2.75^{-22}	6.59^{-21}	5.28^{-22}	7.32^{-21}	6.80^{-22}	7.84^{-21}	7.68^{-22}
43	1101 3021	1101 5100	3.1072	3989	9.73^{-21}	-8.61^{-21}	1.47^{-20}	-7.49^{-21}	2.09^{-20}	-5.58^{-21}	2.45^{-20}	-4.33^{-21}	2.68^{-20}	-3.51^{-21}	2.84^{-20}	-2.88^{-21}
44	1101 3041	1101 5100	3.4614	3581	9.73^{-21}	-8.61^{-21}	1.47^{-20}	-7.49^{-21}	2.09^{-20}	-5.58^{-21}	2.45^{-20}	-4.33^{-21}	2.68^{-20}	-3.51^{-21}	2.84^{-20}	-2.88^{-21}
45	1101 3021	1101 6100	3.4724	3570	2.83^{-20}	-2.61^{-20}	4.16^{-20}	-2.32^{-20}	5.73^{-20}	-1.79^{-20}	6.59^{-20}	-1.45^{-20}	7.13^{-20}	-1.22^{-20}	7.49^{-20}	-1.05^{-20}
46	1101 3041	1101 6100	3.8266	3239	2.83^{-20}	-2.61^{-20}	4.16^{-20}	-2.32^{-20}	5.73^{-20}	-1.79^{-20}	6.59^{-20}	-1.45^{-20}	7.13^{-20}	-1.22^{-20}	7.49^{-20}	-1.05^{-20}
47	1101 2121	1101 3021	7.1108	1743	5.89^{-22}	1.01^{-21}	7.28^{-22}	1.18^{-21}	9.12^{-22}	1.31^{-21}	1.03^{-21}	1.34^{-21}	1.11^{-21}	1.33^{-21}	1.17^{-21}	1.31^{-21}
48	1101 2122	1101 3021	8.3024	1493	5.89^{-22}	1.01^{-21}	7.28^{-22}	1.18^{-21}	9.12^{-22}	1.31^{-21}	1.03^{-21}	1.34^{-21}	1.11^{-21}	1.33^{-21}	1.17^{-21}	1.31^{-21}
49	1101 2121	1102 3029	8.7810	1412	4.35^{-22}	7.60^{-22}	5.29^{-22}	8.97^{-22}	6.61^{-22}	1.03^{-21}	7.54^{-22}	1.09^{-21}	8.23^{-22}	1.11^{-21}	8.74^{-22}	1.11^{-21}
50	1101 2121	1101 4000	9.3013	1333	2.80^{-21}	4.73^{-21}	3.51^{-21}	5.47^{-21}	4.46^{-21}	5.89^{-21}	5.06^{-21}	5.88^{-21}	5.48^{-21}	5.73^{-21}	5.77^{-21}	5.56^{-21}
51	1101 2121	1101 3221	9.3943	1319	1.92^{-21}	3.05^{-21}	2.36^{-21}	3.45^{-21}	2.92^{-21}	3.64^{-21}	3.28^{-21}	3.62^{-21}	3.54^{-21}	3.54^{-21}	3.74^{-21}	3.44^{-21}
52	1101 2121	1101 3222	9.4599	1310	2.30^{-21}	3.52^{-21}	2.79^{-21}	3.90^{-21}	3.36^{-21}	4.01^{-21}	3.71^{-21}	3.93^{-21}	3.96^{-21}	3.79^{-21}	4.14^{-21}	3.66^{-21}
53	1101 2122	1102 3029	9.9726	1243	4.35^{-22}	7.60^{-22}	5.29^{-22}	8.97^{-22}	6.61^{-22}	1.03^{-21}	7.54^{-22}	1.09^{-21}	8.23^{-22}	1.11^{-21}	8.74^{-22}	1.11^{-21}

Table 4-15 (cont.)

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	T = 2500°K		T = 5000°K		T = 10,000°K		T = 15,000°K		T = 20,000°K		T = 25,000°K	
					$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)
54	1101 2121	1101 5000	10.0560	1233	1.08^{-20}	1.76^{-20}	1.37^{-20}	1.99^{-20}	1.73^{-20}	2.05^{-20}	1.94^{-20}	1.97^{-20}	2.07^{-20}	1.88^{-20}	2.16^{-20}	1.79^{-20}
55	1101 2121	1101 4200	10.1015	1227	2.45^{-20}	2.95^{-20}	2.74^{-20}	2.81^{-20}	2.93^{-20}	2.49^{-20}	2.98^{-20}	2.24^{-20}	2.99^{-20}	2.06^{-20}	2.96^{-20}	1.92^{-20}
56	1101 2140	1101 3041	10.3320	1200	4.09^{-22}	7.33^{-22}	4.95^{-22}	8.72^{-22}	6.21^{-22}	1.00^{-21}	7.08^{-22}	1.06^{-21}	7.76^{-22}	1.08^{-21}	8.28^{-22}	1.09^{-21}
57	1101 2121	1101 6000	10.3948	1192	2.98^{-20}	4.76^{-20}	3.80^{-20}	5.24^{-20}	4.78^{-20}	5.20^{-20}	5.34^{-20}	4.91^{-20}	5.70^{-20}	4.62^{-20}	5.93^{-20}	4.36^{-20}
58	1101 2121	1101 5200	10.4175	1190	3.68^{-20}	5.58^{-20}	4.51^{-20}	5.79^{-20}	5.32^{-20}	5.52^{-20}	5.71^{-20}	5.17^{-20}	5.95^{-20}	4.84^{-20}	6.08^{-20}	4.58^{-20}
59	1101 2122	1101 4000	10.4929	1181	2.80^{-21}	4.72^{-21}	3.51^{-20}	5.47^{-21}	4.46^{-21}	5.89^{-21}	5.06^{-21}	5.88^{-21}	5.47^{-21}	5.73^{-21}	5.77^{-21}	5.56^{-21}
60	1101 2122	1101 7000	10.5708	1173	7.21^{-20}	1.10^{-19}	9.24^{-20}	1.18^{-19}	1.16^{-19}	1.12^{-19}	1.28^{-19}	1.04^{-19}	1.35^{-19}	9.66^{-20}	1.40^{-19}	9.00^{-20}
61	1101 2121	1101 6200	10.5846	1171	5.62^{-20}	6.84^{-20}	6.83^{-20}	6.46^{-20}	7.96^{-20}	5.48^{-20}	8.47^{-20}	4.76^{-20}	8.72^{-20}	4.26^{-20}	8.83^{-20}	3.88^{-20}
62	1101 2122	1101 3221	10.5859	1171	1.92^{-21}	3.05^{-21}	2.36^{-21}	3.45^{-21}	2.92^{-21}	3.64^{-21}	3.28^{-21}	3.62^{-21}	3.54^{-21}	3.54^{-21}	3.74^{-21}	3.44^{-21}
63	1101 2122	1101 3223	10.6191	1167	2.10^{-21}	3.29^{-21}	2.56^{-21}	3.69^{-21}	3.12^{-21}	3.85^{-21}	3.46^{-21}	3.81^{-21}	3.71^{-21}	3.70^{-21}	3.89^{-21}	3.58^{-21}
64	1101 2122	1101 3222	10.6515	1164	2.30^{-21}	3.52^{-21}	2.79^{-21}	3.90^{-21}	3.36^{-21}	4.01^{-21}	3.71^{-21}	3.93^{-21}	3.96^{-21}	3.79^{-21}	4.14^{-21}	3.66^{-21}
65	1101 2121	1101 8000	10.6749	1161	1.49^{-19}	2.19^{-19}	1.92^{-19}	2.28^{-19}	2.39^{-19}	2.12^{-19}	2.62^{-19}	1.94^{-19}	2.76^{-19}	1.79^{-19}	2.85^{-19}	1.66^{-19}
66	1101 2121	1101 7200	10.6824	1160	1.99^{-19}	2.56^{-19}	2.39^{-19}	2.35^{-19}	2.68^{-19}	1.93^{-19}	2.77^{-19}	1.64^{-19}	2.79^{-19}	1.45^{-19}	2.78^{-19}	1.31^{-19}
67	1101 2121	1101 8200	10.7567	1152	3.09^{-19}	4.02^{-19}	3.80^{-19}	3.74^{-19}	4.37^{-19}	3.13^{-19}	4.58^{-19}	2.69^{-19}	4.66^{-19}	2.40^{-19}	4.67^{-19}	2.18^{-19}
68	1101 2140	1104 2141	10.9267	1134	1.11^{-23}	1.57^{-23}	1.35^{-23}	1.84^{-23}	1.61^{-23}	2.06^{-23}	1.77^{-23}	2.11^{-23}	1.88^{-23}	2.09^{-23}	1.95^{-23}	2.06^{-23}
69	1101 2122	1102 4000	11.1999	1107	2.83^{-21}	4.79^{-21}	3.54^{-21}	5.56^{-21}	4.46^{-21}	6.01^{-21}	5.03^{-21}	6.02^{-21}	5.43^{-21}	5.87^{-21}	5.71^{-21}	5.69^{-21}
70	1101 2122	1101 5000	11.2476	1102	1.08^{-20}	1.76^{-20}	1.37^{-20}	1.99^{-20}	1.73^{-20}	2.05^{-20}	1.94^{-20}	1.97^{-20}	2.07^{-20}	1.88^{-20}	2.16^{-20}	1.79^{-20}
71	1101 2122	1101 4200	11.2931	1098	2.45^{-20}	2.95^{-20}	2.74^{-20}	2.81^{-20}	2.93^{-20}	2.49^{-20}	2.98^{-20}	2.24^{-20}	2.99^{-20}	2.06^{-20}	2.96^{-20}	1.92^{-20}
72	1101 2121	1102 3221	11.3010	1097	2.11^{-21}	3.34^{-21}	2.61^{-21}	3.78^{-21}	3.23^{-21}	3.98^{-21}	3.60^{-21}	3.93^{-21}	3.85^{-21}	3.82^{-21}	4.05^{-21}	3.68^{-21}
73	1101 2121	1102 3222	11.3193	1095	2.22^{-21}	3.49^{-21}	2.74^{-21}	3.93^{-21}	3.37^{-21}	4.11^{-21}	3.74^{-21}	4.04^{-21}	4.00^{-21}	3.92^{-21}	4.19^{-21}	3.77^{-21}
74	1101 2121	1104 2122	11.5500	1073	3.01^{-23}	3.38^{-23}	3.35^{-23}	3.52^{-23}	3.61^{-23}	3.37^{-23}	3.71^{-23}	3.12^{-23}	3.73^{-23}	2.92^{-23}	3.71^{-23}	2.75^{-23}
75	1101 2122	1101 6000	11.5860	1070	2.98^{-20}	4.76^{-20}	3.80^{-20}	5.24^{-20}	4.78^{-20}	5.20^{-20}	5.34^{-20}	4.91^{-20}	5.70^{-20}	4.62^{-20}	5.93^{-20}	4.36^{-20}
76	1101 2122	1101 5200	11.6090	1068	3.68^{-20}	5.58^{-20}	4.51^{-20}	5.79^{-20}	5.32^{-20}	5.52^{-20}	5.71^{-20}	5.17^{-20}	5.95^{-20}	4.85^{-20}	6.08^{-20}	4.58^{-20}
77	1101 2122	1101 7000	11.7620	1054	7.21^{-20}	1.10^{-19}	9.24^{-20}	1.18^{-19}	1.16^{-19}	1.12^{-19}	1.28^{-19}	1.04^{-19}	1.35^{-19}	9.66^{-20}	1.40^{-19}	9.00^{-20}
78	1101 2122	1101 6200	11.7760	1053	5.62^{-20}	6.84^{-20}	6.83^{-20}	6.46^{-20}	7.96^{-20}	5.48^{-20}	8.47^{-20}	4.76^{-20}	8.72^{-20}	4.26^{-20}	8.83^{-20}	3.88^{-20}
79	1101 2122	1101 8000	11.8660	1044	1.49^{-19}	2.19^{-19}	1.92^{-19}	2.28^{-19}	2.39^{-19}	2.12^{-19}	2.62^{-19}	1.94^{-19}	2.76^{-19}	1.79^{-19}	2.85^{-19}	1.66^{-19}
80	1101 2122	1101 7200	11.8740	1044	1.99^{-19}	2.56^{-19}	2.39^{-19}	2.35^{-19}	2.68^{-19}	1.93^{-19}	2.77^{-19}	1.64^{-19}	2.79^{-19}	1.45^{-19}	2.78^{-19}	1.31^{-19}
81	1101 2122	1101 8200	11.9480	1037	3.09^{-19}	4.02^{-19}	3.80^{-19}	3.74^{-19}	4.37^{-19}	3.13^{-19}	4.58^{-19}	2.69^{-19}	4.66^{-19}	2.40^{-19}	4.67^{-19}	2.18^{-19}
82	1101 2121	1102 4200	12.0000	1033	2.94^{-20}	2.77^{-20}	3.06^{-20}	2.34^{-20}	2.99^{-20}	1.87^{-20}	2.89^{-20}	1.61^{-20}	2.79^{-20}	1.44^{-20}	2.71^{-20}	1.31^{-20}
83	1101 2121	1102 6000	12.2958	1008	3.03^{-20}	5.12^{-20}	3.79^{-20}	5.95^{-20}	4.77^{-20}	6.42^{-20}	5.37^{-20}	6.93^{-20}	5.80^{-20}	6.27^{-20}	6.10^{-20}	6.08^{-20}
84	1101 2121	1102 5200	12.3164	1006	1.08^{-19}	8.96^{-20}	2.01^{-19}	5.81^{-20}	6.96^{-19}	2.22^{-20}	1.29^{-18}	3.34^{-22}	1.82^{-18}	-8.42^{-21}	2.30^{-18}	-7.28^{-21}
85	1101 2122	1102 4000	12.3915	1000	2.83^{-21}	4.79^{-21}	3.54^{-21}	5.56^{-21}	4.46^{-21}	6.01^{-21}	5.03^{-21}	6.02^{-21}	5.43^{-21}	5.87^{-21}	5.71^{-21}	5.69^{-21}
86	1101 2122	1102 3223	12.4365	992.1	2.22^{-21}	3.49^{-21}	2.79^{-21}	3.93^{-21}	3.37^{-21}	4.11^{-21}	3.74^{-21}	4.04^{-21}	4.00^{-21}	3.92^{-21}	4.19^{-21}	3.77^{-21}
87	1101 2122	1102 3221	12.4934	992.1	2.22^{-21}	3.49^{-21}	2.79^{-21}	3.93^{-21}	3.37^{-21}	4.11^{-21}	3.74^{-21}	4.04^{-21}	4.00^{-21}	3.92^{-21}	4.19^{-21}	3.77^{-21}
88	1101 2122	1102 3222	12.5109	990.7	2.22^{-21}	3.49^{-21}	2.79^{-21}	3.93^{-21}	3.37^{-21}	4.11^{-21}	3.74^{-21}	4.04^{-21}	4.00^{-21}	3.92^{-21}	4.19^{-21}	3.77^{-21}
89	1101 2140	1101 4000	12.8768	962.6	2.80^{-21}	4.73^{-21}	3.51^{-21}	5.47^{-21}	4.46^{-21}	5.89^{-21}	5.06^{-21}	5.88^{-21}	5.48^{-21}	5.73^{-21}	5.77^{-21}	5.56^{-21}
90	1101 2140	1101 3241	13.0039	953.2	1.47^{-21}	1.52^{-21}	2.11^{-21}	1.23^{-21}	2.94^{-21}	6.25^{-22}	3.53^{-21}	1.31^{-22}	3.99^{-21}	-2.19^{-22}	4.36^{-21}	-4.86^{-22}
91	1101 2122	1102 5000	13.1466	942.8	6.40^{-21}	1.11^{-20}	7.62^{-21}	1.34^{-20}	9.43^{-21}	1.56^{-20}	1.09^{-20}	1.65^{-20}	1.19^{-20}	1.69^{-20}	1.27^{-20}	1.70^{-20}
92	1101 2122	1102 4200	13.1900	939.7	2.94^{-20}	2.77^{-20}	3.06^{-20}	2.34^{-20}	2.99^{-20}	1.87^{-20}	2.89^{-20}	1.61^{-20}	2.79^{-20}	1.44^{-20}	2.71^{-20}	1.31^{-20}
93	1101 2122	1102 6000	13.4850	919.2	3.03^{-20}	5.12^{-20}	3.79^{-20}	5.95^{-20}	4.77^{-20}	6.42^{-20}	5.37^{-20}	6.43^{-20}	5.80^{-20}	6.27^{-20}	6.10^{-20}	6.08^{-20}
94	1101 2122	1102 5200	13.5080	917.6	1.08^{-19}	8.96^{-20}	2.01^{-19}	5.81^{-20}	6.96^{-19}	2.22^{-20}	1.29^{-18}	3.34^{-22}	1.82^{-18}	-8.42^{-21}	2.30^{-18}	-7.28^{-21}
95	1101 2140	1101 5000	13.6310	909.3	1.08^{-20}	1.76^{-20}	1.37^{-20}	1.99^{-20}	1.73^{-20}	2.05^{-20}	1.94^{-20}	1.97^{-20}	2.07^{-20}	1.88^{-20}	2.16^{-20}	1.79^{-20}
96	1101 2140	1101 4200	13.6770	906.3	2.45^{-20}	2.95^{-20}	2.74^{-20}	2.81^{-20}	2.93^{-20}	2.49^{-20}	2.98^{-20}	2.24^{-20}	2.99^{-20}	2.06^{-20}	2.96^{-20}	1.92^{-20}
97	1101 2140	1101 6000	13.9703	887.2	2.98^{-20}	4.76^{-20}	3.80^{-20}	5.24^{-20}	4.78^{-20}	5.20^{-20}	5.34^{-20}	4.91^{-20}	5.70^{-20}	4.62^{-20}	5.93^{-20}	4.36^{-20}
98	1101 2140	1101 5200	13.993	885.8	3.68^{-20}	5.58^{-20}	4.51^{-20}	5.79^{-20}	5.32^{-20}	5.52^{-20}	5.71^{-20}	5.17^{-20}	5.95^{-20}	4.85^{-20}	6.08^{-20}	4.58^{-20}
99	1101 2140	1101 7000	14.1463	876.2	7.21^{-20}	1.10^{-19}	9.24^{-20}	1.18^{-19}	1.16^{-19}	1.12^{-19}	1.28^{-19}	1.04^{-19}	1.35^{-19}	9.66^{-20}	1.40^{-19}	9.00^{-20}
100	1101 2140	1101 6200	14.1601	874.3	5.62^{-20}	6.84^{-20}	6.83^{-20}	6.46^{-20}	7.96^{-20}	5.48^{-20}	8.47^{-20}	4.76^{-20}	8.72^{-20}	4.26^{-20}	8.83^{-20}	3.88^{-20}
101	1101 2140	1101 8000	14.2504	869.8	1.49^{-19}	2.19^{-19}	1.92^{-19}	2.28^{-19}	2.39^{-19}	2.12^{-19}	2.62^{-19}	1.94^{-19}	2.76^{-19}	1.79^{-19}	2.85^{-19}	1.66^{-19}
102	1101 2140	1101 7200	14.2570	869.4	1.99^{-19}	2.56^{-19}	2.39^{-19}	2.35^{-19}	2.68^{-19}	1.93^{-19}	2.77^{-19}	1.64^{-19}	2.79^{-19}	1.45^{-19}	2.78^{-19}	1.31^{-19}
103	1101 2140	1101 8200	14.3320	852.9	3.09^{-19}	4.02^{-19}	3.80^{-19}	3.74^{-19}	4.37^{-19}	3.13^{-19}	4.58^{-19}	2.69^{-19}	4.66^{-19}	2.40^{-19}	4.67^{-19}	2.18^{-19}

Table 4-16

ATOMIC LINE TRANSITIONS FOR SINGLY IONIZED NITROGEN, NII – ELECTRON IMPACT HALF-WIDTHS AND LINE SHAPES

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	T = 2500°K		T = 5000°K		T = 10,000°K	
					$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)
1	1201 2131	1202 2132	11.4240	1085	1.00^{-23}	1.66^{-23}	1.19^{-23}	1.94^{-23}	1.43^{-23}	2.32^{-23}
2	1201 2131	1202 2131	13.5435	915.2	6.63^{-24}	1.10^{-23}	7.91^{-24}	1.28^{-23}	9.50^{-24}	1.53^{-23}
3	1201 2110	1201 3011	14.4590	857.3	2.12^{-22}	3.84^{-22}	2.57^{-22}	4.54^{-22}	3.26^{-22}	5.18^{-22}
4	1201 2112	1202 2112	15.9931	769.4	9.02^{-24}	1.39^{-23}	1.08^{-23}	1.64^{-23}	1.29^{-23}	1.95^{-23}
5	1201 2112	1201 3011	16.6134	746.1	2.12^{-22}	3.84^{-22}	2.57^{-22}	4.54^{-22}	3.26^{-22}	5.18^{-22}
6	1201 2110	1202 2111	16.6381	745.0	1.17^{-23}	1.69^{-23}	1.38^{-23}	2.01^{-23}	1.64^{-23}	2.36^{-23}
7	1201 2131	1201 3031	18.4690	671.1	1.93^{-22}	3.45^{-22}	2.32^{-22}	4.12^{-22}	2.92^{-22}	4.74^{-22}
8	1201 2112	1202 2111	18.792	659.4	1.17^{-23}	1.69^{-23}	1.38^{-23}	2.01^{-23}	1.64^{-23}	2.36^{-23}
9	1201 2131	1202 2130	19.2355	644.4	1.01^{-23}	1.51^{-23}	1.20^{-23}	1.80^{-23}	1.43^{-23}	2.13^{-23}
10	1201 2110	1201 3211	19.534	634.5	3.21^{-21}	-2.03^{-23}	3.98^{-21}	6.50^{-24}	8.77^{-21}	-7.62^{-24}

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	T = 15,000°K		T = 20,000°K		T = 25,000°K	
					$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)
1	1201 2131	1202 2132	11.4240	1085	1.61^{-23}	2.53^{-23}	1.76^{-23}	2.67^{-23}	1.88^{-23}	2.74^{-23}
2	1201 2131	1202 2131	13.5435	915.2	1.07^{-23}	1.68^{-23}	1.17^{-23}	1.78^{-23}	1.25^{-23}	1.84^{-23}
3	1201 2110	1201 3011	14.4590	857.3	3.73^{-22}	5.44^{-22}	4.09^{-22}	5.52^{-22}	4.35^{-22}	5.56^{-22}
4	1201 2112	1202 2112	15.9931	769.4	1.44^{-23}	2.12^{-23}	1.56^{-23}	2.20^{-23}	1.67^{-23}	2.24^{-23}
5	1201 2112	1201 3011	16.6134	746.1	3.73^{-22}	5.44^{-22}	4.09^{-22}	5.52^{-22}	4.33^{-22}	5.56^{-22}
6	1201 2110	1202 2111	16.6381	745.0	1.81^{-23}	2.51^{-23}	1.97^{-23}	2.56^{-23}	2.07^{-23}	2.57^{-23}
7	1201 2131	1201 3031	18.4690	671.1	3.35^{-22}	5.03^{-22}	3.68^{-22}	5.14^{-22}	3.92^{-22}	5.19^{-22}
8	1201 2112	1202 2111	18.792	659.4	1.81^{-23}	2.51^{-23}	1.97^{-23}	2.57^{-23}	2.07^{-23}	2.57^{-23}
9	1201 2131	1202 2130	19.2355	644.4	1.60^{-23}	2.29^{-23}	1.73^{-23}	2.36^{-23}	1.84^{-23}	2.39^{-23}
10	1201 2110	1201 3211	19.534	634.5	1.23^{-20}	2.63^{-25}	1.40^{-20}	2.21^{-23}	1.48^{-20}	9.47^{-24}

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Table 4-17

ATOMIC LINE TRANSITIONS FOR NEUTRAL OXYGEN, OI – ELECTRON IMPACT HALF-WIDTHS AND LINE SHIFTS

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	T = 2500°K		T = 5000°K		T = 10,000°K		T = 15,000°K		T = 20,000°K		T = 25,000°K	
					$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)
1	0101 3232	0101 4100	0.226	54845	2.26^{-21}	-1.59^{-21}	3.56^{-21}	-1.13^{-21}	5.20^{-21}	-5.70^{-22}	6.21^{-21}	-2.79^{-22}	6.88^{-21}	-8.96^{-23}	7.35^{-21}	3.32^{-23}
2	0101 3252	0101 4100	0.235	52745	2.26^{-21}	-1.59^{-21}	3.56^{-21}	-1.13^{-21}	5.20^{-21}	-5.70^{-22}	6.21^{-21}	-2.79^{-22}	6.88^{-21}	-8.96^{-23}	7.35^{-21}	3.32^{-23}
3	0101 3232	0101 4300	0.681	18201	1.56^{-20}	-1.61^{-20}	1.68^{-20}	-1.40^{-20}	1.69^{-20}	-1.12^{-20}	1.63^{-20}	-9.56^{-21}	1.57^{-20}	-8.49^{-21}	1.51^{-20}	-7.72^{-21}
4	0101 3252	0101 4300	0.689	17990	1.56^{-20}	-1.61^{-20}	1.68^{-20}	-1.40^{-20}	1.69^{-20}	-1.12^{-20}	1.63^{-20}	-9.56^{-21}	1.57^{-20}	-8.49^{-21}	1.51^{-20}	-7.72^{-21}
5	0101 3232	0101 5100	0.770	16097	5.73^{-21}	-4.14^{-21}	8.26^{-21}	-4.08^{-21}	1.10^{-20}	-3.80^{-21}	1.23^{-20}	-3.54^{-21}	1.31^{-20}	-3.31^{-21}	1.36^{-20}	-3.14^{-21}
6	0101 3252	0101 5100	0.779	15911	5.73^{-21}	-4.14^{-21}	8.26^{-21}	-4.08^{-21}	1.10^{-20}	-3.80^{-21}	1.23^{-20}	-3.54^{-21}	1.31^{-20}	-3.31^{-21}	1.36^{-20}	-3.14^{-21}
7	0101 3131	0101 4000	0.884	14021	2.30^{-21}	3.91^{-21}	2.88^{-21}	4.57^{-21}	3.67^{-21}	4.96^{-21}	4.19^{-21}	4.98^{-21}	4.54^{-21}	4.88^{-21}	4.82^{-21}	4.74^{-21}
8	0101 3232	0101 5300	0.987	12558	2.10^{-20}	-3.14^{-20}	2.62^{-20}	-3.22^{-20}	3.09^{-20}	-3.01^{-20}	3.28^{-20}	-2.79^{-20}	3.38^{-20}	-2.59^{-20}	3.42^{-20}	-2.43^{-20}
9	0101 3252	0101 5300	0.995	12457	2.10^{-20}	-3.14^{-20}	2.62^{-20}	-3.22^{-20}	3.09^{-20}	-3.01^{-20}	3.28^{-20}	-2.70^{-20}	3.38^{-20}	-2.59^{-20}	3.42^{-20}	-2.43^{-20}
10	0101 3131	0101 3232	1.098	11289	2.37^{-21}	3.67^{-21}	2.87^{-21}	4.09^{-21}	3.44^{-21}	4.23^{-21}	3.78^{-21}	4.17^{-21}	4.02^{-21}	4.03^{-21}	4.20^{-21}	3.90^{-21}
11	0101 3151	0101 4000	1.132	10950	2.30^{-21}	3.91^{-21}	2.88^{-21}	4.57^{-21}	3.67^{-21}	4.96^{-21}	4.19^{-21}	4.98^{-21}	4.54^{-21}	4.88^{-21}	4.82^{-21}	4.74^{-21}
12	0101 3151	0101 3252	1.338	9263	2.39^{-21}	3.73^{-21}	2.87^{-21}	4.20^{-21}	3.42^{-21}	4.45^{-21}	3.73^{-21}	4.46^{-21}	3.94^{-21}	4.37^{-21}	4.09^{-21}	4.26^{-21}
13	0101 3030	0101 3131	1.467	8449	5.30^{-22}	8.94^{-22}	6.64^{-22}	1.04^{-21}	8.65^{-22}	1.16^{-21}	1.01^{-21}	1.18^{-21}	1.11^{-21}	1.18^{-21}	1.20^{-21}	1.16^{-21}
14	0101 3050	0101 3151	1.594	7776	4.33^{-22}	7.41^{-22}	5.41^{-22}	8.70^{-22}	7.09^{-22}	9.79^{-22}	8.36^{-22}	1.01^{-21}	9.33^{-22}	1.02^{-21}	1.01^{-21}	1.01^{-21}
15	0101 3131	0101 5000	1.683	7365	8.94^{-21}	1.47^{-20}	1.13^{-20}	1.67^{-20}	1.45^{-20}	1.73^{-20}	1.64^{-20}	1.68^{-20}	1.77^{-20}	1.61^{-20}	1.86^{-20}	1.53^{-20}
16	0101 3131	0101 4200	1.767	7015	9.65^{-21}	1.34^{-20}	1.14^{-20}	1.40^{-20}	1.32^{-20}	1.34^{-20}	1.41^{-20}	1.25^{-20}	1.47^{-20}	1.18^{-20}	1.50^{-20}	1.11^{-20}
17	0101 3151	0101 5000	1.931	6419	8.94^{-21}	1.47^{-20}	1.13^{-20}	1.67^{-20}	1.45^{-20}	1.73^{-20}	1.64^{-20}	1.68^{-20}	1.77^{-20}	1.61^{-20}	1.86^{-20}	1.53^{-20}
18	0101 3151	0101 4200	2.015	6151	9.65^{-21}	1.34^{-20}	1.14^{-20}	1.40^{-20}	1.32^{-20}	1.34^{-20}	1.41^{-20}	1.25^{-20}	1.47^{-20}	1.18^{-20}	1.50^{-20}	1.11^{-20}
19	0101 3131	0101 5200	2.079	5962	3.66^{-20}	5.68^{-20}	4.55^{-20}	6.19^{-20}	5.49^{-20}	6.09^{-20}	5.95^{-20}	5.76^{-20}	6.24^{-20}	5.43^{-20}	6.41^{-20}	5.13^{-20}
20	0101 3151	0101 5200	2.327	5327	3.66^{-20}	5.68^{-20}	4.55^{-20}	6.19^{-20}	5.49^{-20}	6.09^{-20}	5.95^{-20}	5.76^{-20}	6.24^{-20}	5.43^{-20}	6.41^{-20}	5.13^{-20}
21	0101 3030	0101 4100	2.792	4439	2.26^{-21}	-1.59^{-21}	3.56^{-21}	-1.13^{-21}	5.20^{-21}	-5.70^{-22}	6.21^{-21}	-2.79^{-22}	6.88^{-21}	-8.96^{-23}	7.35^{-21}	3.32^{-23}
22	0101 3050	0101 4100	3.167	3914	2.26^{-21}	-1.59^{-21}	3.56^{-21}	-1.13^{-21}	5.20^{-21}	-5.70^{-22}	6.21^{-21}	-2.79^{-22}	6.88^{-21}	-8.96^{-23}	7.35^{-21}	3.32^{-23}
23	0101 3030	0101 5100	3.336	3716	5.73^{-21}	-4.14^{-21}	8.26^{-21}	-4.08^{-21}	1.10^{-20}	-3.80^{-21}	1.23^{-20}	-3.54^{-21}	1.31^{-20}	-3.31^{-21}	1.36^{-20}	-3.14^{-21}
24	0101 3050	0101 5100	3.711	3340	5.73^{-21}	-4.14^{-21}	8.26^{-21}	-4.08^{-21}	1.10^{-20}	-3.80^{-21}	1.23^{-20}	-3.54^{-21}	1.31^{-20}	-3.31^{-21}	1.36^{-20}	-3.14^{-21}
25	0101 2131	0101 3030	9.501	1305	3.62^{-22}	6.63^{-22}	4.34^{-22}	7.91^{-22}	5.48^{-22}	9.08^{-22}	6.29^{-22}	9.51^{-22}	6.92^{-22}	9.65^{-22}	7.37^{-22}	9.67^{-22}
26	0101 2110	0103 3011	10.182	1217	4.25^{-22}	7.37^{-22}	5.21^{-22}	8.68^{-22}	6.53^{-22}	9.87^{-22}	7.42^{-22}	1.03^{-21}	8.05^{-22}	1.04^{-21}	8.53^{-22}	1.03^{-21}
27	0101 2112	0102 3012	10.761	1152	4.25^{-22}	7.37^{-22}	5.21^{-22}	8.68^{-22}	6.53^{-22}	9.87^{-22}	7.42^{-22}	1.03^{-21}	8.05^{-22}	1.04^{-21}	8.53^{-22}	1.03^{-21}
28	0101 2110	0102 4000	11.007	1126	2.33^{-21}	3.95^{-21}	2.90^{-21}	4.63^{-21}	3.67^{-21}	5.04^{-21}	4.17^{-21}	5.07^{-21}	4.51^{-21}	4.97^{-21}	4.78^{-21}	4.83^{-21}
29	0101 2110	0102 5000	11.806	1050	8.91^{-21}	1.47^{-20}	1.13^{-20}	1.67^{-20}	1.45^{-20}	1.73^{-20}	1.64^{-20}	1.67^{-20}	1.77^{-20}	1.60^{-20}	1.86^{-20}	1.53^{-20}
30	0101 2110	0101 4000	11.852	1046	2.30^{-21}	3.91^{-21}	2.88^{-21}	4.57^{-21}	3.67^{-21}	4.96^{-21}	4.19^{-21}	4.98^{-21}	4.54^{-21}	4.88^{-21}	4.82^{-21}	4.74^{-21}
31	0101 2131	0101 3232	12.067	1027	2.37^{-21}	3.67^{-21}	2.87^{-21}	4.09^{-21}	3.44^{-21}	4.23^{-21}	3.78^{-21}	4.17^{-21}	4.02^{-21}	4.03^{-21}	4.20^{-21}	3.90^{-21}
32	0101 2110	0102 6000	12.160	1019	8.45^{-21}	-1.38^{-20}	1.05^{-20}	-1.55^{-20}	1.28^{-20}	-1.60^{-20}	1.40^{-20}	-1.55^{-20}	1.47^{-20}	-1.48^{-20}	1.51^{-20}	-1.42^{-20}
33	0101 2112	0103 3011	12.404	997.7	4.25^{-22}	7.37^{-22}	5.21^{-22}	8.68^{-22}	6.53^{-22}	9.87^{-22}	7.42^{-22}	1.03^{-21}	8.05^{-22}	1.04^{-21}	8.53^{-22}	1.03^{-21}
34	0101 2131	0102 3032	12.521	989.9	4.13^{-22}	7.18^{-22}	5.05^{-22}	8.46^{-22}	6.33^{-22}	9.65^{-22}	7.20^{-22}	1.01^{-21}	7.82^{-22}	1.02^{-21}	8.29^{-22}	1.01^{-21}
35	0101 2131	0101 5000	12.651	979.8	8.94^{-21}	1.47^{-20}	1.13^{-20}	1.67^{-20}	1.45^{-20}	1.73^{-20}	1.64^{-20}	1.68^{-20}	1.77^{-20}	1.61^{-20}	1.86^{-20}	1.53^{-20}
36	0101 2110	0103 4000	12.699	976.1	2.33^{-21}	3.95^{-21}	2.90^{-21}	4.63^{-21}	3.67^{-21}	5.04^{-21}	4.17^{-21}	5.07^{-21}	4.51^{-21}	4.97^{-21}	4.78^{-21}	4.83^{-21}
37	0101 2131	0101 4200	12.735	973.3	9.65^{-21}	1.34^{-20}	1.14^{-20}	1.40^{-20}	1.32^{-20}	1.34^{-20}	1.41^{-20}	1.25^{-20}	1.47^{-20}	1.18^{-20}	1.50^{-20}	1.11^{-20}
38	0101 2110	0103 3219	12.911	960.0	4.25^{-22}	7.37^{-22}	5.21^{-22}	8.68^{-22}	6.53^{-22}	9.87^{-22}	7.42^{-22}	1.03^{-21}	8.05^{-22}	1.04^{-21}	8.53^{-22}	1.03^{-21}
39	0101 2131	0101 6000	13.005	953.1	2.60^{-20}	4.16^{-20}	3.33^{-20}	4.58^{-20}	4.23^{-20}	4.55^{-20}	4.76^{-20}	4.30^{-20}	5.09^{-20}	4.04^{-20}	5.32^{-20}	3.82^{-20}
40	0101 2131	0101 5200	13.047	950.0	3.66^{-20}	5.68^{-20}	4.55^{-20}	6.19^{-20}	5.49^{-20}	6.09^{-20}	5.95^{-20}	5.76^{-20}	6.24^{-20}	5.43^{-20}	6.41^{-20}	5.13^{-20}

Table 4-17 (cont.)

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	T = 2500°K		T = 5000°K		T = 10,000°K		T = 15,000°K		T = 20,000°K		T = 25,000°K	
					$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)
41	0101 2112	0102 3212	13.220	937.6	4.25^{-22}	7.37^{-22}	5.21^{-22}	8.68^{-22}	6.53^{-22}	9.87^{-22}	7.42^{-22}	1.03^{-21}	8.05^{-22}	1.04^{-21}	8.53^{-22}	1.03^{-21}
42	0101 2112	0102 4000	13.229	937.0	2.33^{-21}	3.95^{-21}	2.90^{-21}	4.63^{-21}	3.67^{-21}	5.04^{-21}	4.17^{-21}	5.07^{-21}	4.51^{-21}	4.97^{-21}	4.78^{-21}	4.83^{-21}
43	0101 2131	0101 6200	13.232	936.7	1.85^{-19}	2.25^{-19}	2.12^{-19}	2.12^{-19}	2.28^{-19}	1.82^{-19}	2.31^{-19}	1.60^{-19}	2.30^{-19}	1.44^{-19}	2.27^{-19}	1.32^{-19}
44	0101 2131	0101 7200	13.331	929.8	4.30^{-19}	4.23^{-19}	4.58^{-19}	3.57^{-19}	4.55^{-19}	2.78^{-19}	4.40^{-19}	2.33^{-19}	4.23^{-19}	2.04^{-19}	4.08^{-19}	1.83^{-19}
45	0101 2131	0101 8200	13.394	925.4	6.65^{-19}	6.71^{-19}	7.13^{-19}	5.75^{-19}	7.06^{-19}	4.55^{-19}	6.81^{-19}	3.85^{-19}	6.52^{-19}	3.41^{-19}	6.26^{-19}	3.08^{-19}
46	0101 2112	0102 3213	13.447	921.8	2.50^{-21}	3.93^{-21}	3.02^{-21}	4.43^{-21}	3.61^{-21}	4.69^{-21}	3.94^{-21}	4.67^{-21}	4.16^{-21}	4.57^{-21}	4.31^{-21}	4.44^{-21}
47	0101 2110	0103 5000	13.498	918.3	8.19^{-21}	1.47^{-20}	1.13^{-20}	1.67^{-20}	1.45^{-20}	1.73^{-20}	1.64^{-20}	1.67^{-20}	1.77^{-20}	1.60^{-20}	1.86^{-20}	1.53^{-20}
48	0101 2112	0102 3211	13.555	914.4	1.81^{-21}	2.93^{-21}	2.23^{-21}	3.36^{-21}	2.74^{-21}	3.66^{-21}	3.06^{-21}	3.70^{-21}	3.29^{-21}	3.65^{-21}	3.45^{-21}	3.58^{-21}
49	0101 2110	0103 4200	13.582	912.6	4.38^{-20}	4.74^{-20}	4.54^{-20}	4.62^{-20}	4.59^{-20}	4.54^{-20}	4.64^{-20}	4.46^{-20}	4.68^{-20}	4.37^{-20}	4.71^{-20}	4.29^{-20}
50	0101 2110	0103 6000	13.852	894.8	8.45^{-21}	-1.38^{-20}	1.05^{-20}	-1.55^{-20}	1.28^{-20}	-1.60^{-20}	1.40^{-20}	-1.55^{-20}	1.47^{-20}	-1.48^{-20}	1.51^{-20}	-1.42^{-20}
51	0101 2110	0103 5200	13.894	892.1	4.86^{-20}	-2.01^{-21}	7.46^{-20}	-1.02^{-21}	1.04^{-19}	-3.51^{-21}	1.08^{-19}	-2.06^{-21}	1.07^{-19}	-1.39^{-21}	1.03^{-19}	-8.87^{-22}
52	0101 2112	0102 5000	14.029	883.5	8.91^{-21}	1.47^{-20}	1.13^{-20}	1.67^{-20}	1.45^{-20}	1.73^{-20}	1.64^{-20}	1.67^{-20}	1.77^{-20}	1.60^{-20}	1.86^{-20}	1.53^{-20}
53	0101 2131	0103 3031	14.104	878.8	4.13^{-22}	7.18^{-22}	5.05^{-22}	8.46	6.33^{-22}	9.65^{-22}	7.20^{-22}	1.01^{-21}	7.82^{-22}	1.02^{-21}	8.29^{-22}	1.01^{-21}
54	0101 2112	0102 4200	14.113	878.3	4.38^{-20}	4.74^{-20}	4.54^{-20}	4.62^{-20}	4.59^{-20}	4.54^{-20}	4.64^{-20}	4.46^{-20}	4.68^{-20}	4.37^{-20}	4.71^{-20}	4.29^{-20}
55	0101 2112	0102 6000	14.382	861.8	8.45^{-21}	-1.38^{-20}	1.05^{-20}	-1.55^{-20}	1.28^{-20}	-1.60^{-20}	1.40^{-20}	-1.55^{-20}	1.47^{-20}	-1.48^{-20}	1.51^{-20}	-1.42^{-20}
56	0101 2112	0102 5200	14.425	859.3	4.86^{-20}	-2.01^{-21}	7.46^{-20}	-1.02^{-21}	1.04^{-19}	-3.51^{-21}	1.08^{-19}	-2.06^{-21}	1.07^{-19}	-1.39^{-21}	1.03^{-19}	-8.87^{-22}
57	0101 2112	0103 4000	14.921	830.7	2.33^{-21}	3.95^{-21}	2.90^{-21}	4.63^{-21}	3.67^{-21}	5.04^{-21}	4.17^{-21}	5.07^{-21}	4.51^{-21}	4.97^{-21}	4.78^{-21}	4.83^{-21}
58	0101 2131	0102 4000	15.177	816.7	2.33^{-21}	3.95^{-21}	2.90^{-21}	4.63^{-21}	3.67^{-21}	5.04^{-21}	4.17^{-21}	5.07^{-21}	4.51^{-21}	4.97^{-21}	4.78^{-21}	4.83^{-21}
59	0101 2131	0102 3230	15.273	811.6	1.81^{-21}	2.93^{-21}	2.23^{-21}	3.36^{-21}	2.74^{-21}	3.66^{-21}	3.06^{-21}	3.70^{-21}	3.28^{-21}	3.65^{-21}	3.45^{-21}	3.58^{-21}
60	0101 2131	0102 3231	15.273	811.6	1.81^{-21}	2.94^{-21}	2.23^{-21}	3.37^{-21}	2.74^{-21}	3.66^{-21}	3.06^{-21}	3.70^{-21}	3.29^{-21}	3.65^{-21}	3.46^{-21}	3.58^{-21}
61	0101 2131	0102 3232	15.401	804.8	2.51^{-21}	3.88^{-21}	3.01^{-21}	4.34^{-21}	3.56^{-21}	4.56^{-21}	3.86^{-21}	4.54^{-21}	4.07^{-21}	4.44^{-21}	4.22^{-21}	4.32^{-21}
62	0101 2112	0103 5000	15.721	788.4	8.91^{-21}	1.47^{-20}	1.13^{-20}	1.67^{-20}	1.45^{-20}	1.73^{-20}	1.64^{-20}	1.67^{-20}	1.77^{-20}	1.60^{-20}	1.86^{-20}	1.53^{-20}
63	0101 2112	0103 4200	15.805	784.2	4.38^{-20}	4.74^{-20}	4.54^{-20}	4.62^{-20}	4.59^{-20}	4.54^{-20}	4.64^{-20}	4.46^{-20}	4.68^{-20}	4.37^{-20}	4.71^{-20}	4.29^{-20}
64	0101 2131	0102 5000	15.976	775.9	8.91^{-21}	1.47^{-20}	1.13^{-20}	1.67^{-20}	1.45^{-20}	1.73^{-20}	1.64^{-20}	1.67^{-20}	1.77^{-20}	1.60^{-20}	1.86^{-20}	1.53^{-20}
65	0101 2131	0102 4200	16.060	771.8	4.38^{-20}	4.74^{-20}	4.54^{-20}	4.62^{-20}	4.59^{-20}	4.54^{-20}	4.64^{-20}	4.46^{-20}	4.68^{-20}	4.37^{-20}	4.71^{-20}	4.29^{-20}
66	0101 2112	0103 6000	16.074	771.1	8.45^{-21}	-1.38^{-20}	1.05^{-20}	-1.55^{-20}	1.28^{-20}	-1.60^{-20}	1.40^{-20}	-1.55^{-20}	1.47^{-20}	-1.48^{-20}	1.51^{-20}	-1.42^{-20}
67	0101 2112	0103 5200	16.117	769.1	4.86^{-20}	-2.01^{-21}	7.46^{-20}	-1.02^{-21}	1.04^{-19}	-3.51^{-21}	1.08^{-19}	-2.06^{-21}	1.07^{-19}	-1.39^{-21}	1.03^{-19}	-8.87^{-22}
68	0101 2131	0102 6000	16.330	759.0	8.45^{-21}	-1.38^{-20}	1.05^{-20}	-1.55^{-20}	1.28^{-20}	-1.60^{-20}	1.40^{-20}	-1.55^{-20}	1.47^{-20}	-1.48^{-20}	1.51^{-20}	-1.42^{-20}
69	0101 2131	0102 5200	16.372	757.1	4.86^{-20}	-2.01^{-21}	7.46^{-20}	-1.02^{-21}	1.04^{-19}	-3.51^{-21}	1.08^{-19}	-2.06^{-21}	1.07^{-19}	-1.39^{-21}	1.03^{-19}	-8.87^{-22}
70	0101 2131	0103 4000	16.869	734.8	2.33^{-21}	3.95^{-21}	2.90^{-21}	4.63^{-21}	2.67^{-21}	5.04^{-21}	4.17^{-21}	5.07^{-21}	4.51^{-21}	4.97^{-21}	4.78^{-21}	4.83^{-21}
71	0101 2131	0103 3239	17.080	725.7	2.51^{-21}	3.88^{-21}	3.01^{-21}	4.34^{-21}	3.56^{-21}	4.56^{-21}	3.86^{-21}	4.54^{-21}	4.07^{-21}	4.44^{-21}	4.22^{-21}	4.32^{-21}
72	0101 2131	0103 5000	17.668	701.6	8.91^{-21}	1.47^{-20}	1.13^{-20}	1.67^{-20}	1.45^{-20}	1.73^{-20}	1.64^{-20}	1.67^{-20}	1.77^{-20}	1.60^{-20}	1.86^{-20}	1.53^{-20}
73	0101 2131	0103 4200	17.752	698.2	4.38^{-20}	4.74^{-20}	4.54^{-20}	4.62^{-20}	4.59^{-20}	4.54^{-20}	4.64^{-20}	4.46^{-20}	4.68^{-20}	4.37^{-20}	4.71^{-20}	4.29^{-20}
74	0101 2131	0103 6000	18.022	687.8	8.45^{-21}	-1.38^{-20}	1.05^{-20}	-1.55^{-20}	1.28^{-20}	-1.60^{-20}	1.40^{-20}	-1.55^{-20}	1.47^{-20}	-1.48^{-20}	1.51^{-20}	-1.42^{-20}
75	0101 2131	0103 5200	18.064	686.2	4.86^{-20}	-2.01^{-21}	7.46^{-20}	-1.02^{-21}	1.04^{-19}	-3.51^{-21}	1.08^{-19}	-2.06^{-21}	1.07^{-19}	-1.39^{-21}	1.03^{-19}	-8.87^{-22}

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Table 4-18

ATOMIC LINE TRANSITIONS FOR SINGLY IONIZED OXYGEN, OII – ELECTRON IMPACT HALF-WIDTHS AND LINE SHIFTS

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	T = 2500°K		T = 5000°K		T = 10,000°K	
					$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)
1	0201 2140	0204 2141	14.877	833.2	4.87^{-24}	-2.36^{-24}	1.18^{-23}	-1.38^{-24}	1.64^{-23}	3.98^{-25}
2	0201 2121	0204 2122	15.561	796.5	2.83^{-24}	3.23^{-24}	3.96^{-24}	3.71^{-24}	5.98^{-24}	4.44^{-24}
3	0201 2122	0204 2122	17.255	718.4	2.83^{-24}	3.23^{-24}	3.96^{-24}	3.71^{-24}	5.98^{-24}	4.44^{-24}
4	0201 2121	0201 3021	18.423	672.8	1.99^{-22}	3.60^{-22}	2.43^{-22}	4.24^{-22}	3.08^{-22}	4.80^{-22}
5	0201 2121	0204 2120	19.246	644.0	3.98^{-24}	-6.26^{-24}	5.09^{-24}	-7.07^{-24}	6.24^{-24}	-8.29^{-24}

No.	Lower State (ID Code)	Upper State (ID Code)	Energy Difference (eV)	Photon Wavelength (Å)	T = 15,000°K		T = 20,000°K		T = 25,000°K	
					$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)	$\gamma_{nn'}$ (eV)	$d_{nn'}$ (eV)
1	0201 2140	0204 2141	14.877	833.2	1.30^{-23}	-2.29^{-25}	1.37^{-23}	-9.05^{-25}	1.37^{-23}	2.61^{-25}
2	0201 2121	0204 2122	15.561	796.5	7.71^{-24}	4.91^{-24}	9.36^{-24}	5.19^{-24}	1.07^{-23}	5.37^{-24}
3	0201 2122	0204 2122	17.255	718.4	7.71^{-24}	4.91^{-24}	9.36^{-24}	5.19^{-24}	1.07^{-23}	5.37^{-24}
4	0201 2121	0201 3021	18.423	672.8	3.52^{-22}	5.01^{-22}	3.83^{-22}	5.06^{-22}	4.06^{-22}	5.05^{-22}
5	0201 2121	0204 2120	19.246	644.0	6.91^{-24}	-9.13^{-24}	7.39^{-24}	-9.66^{-24}	7.78^{-24}	-9.99^{-24}

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Section 5
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